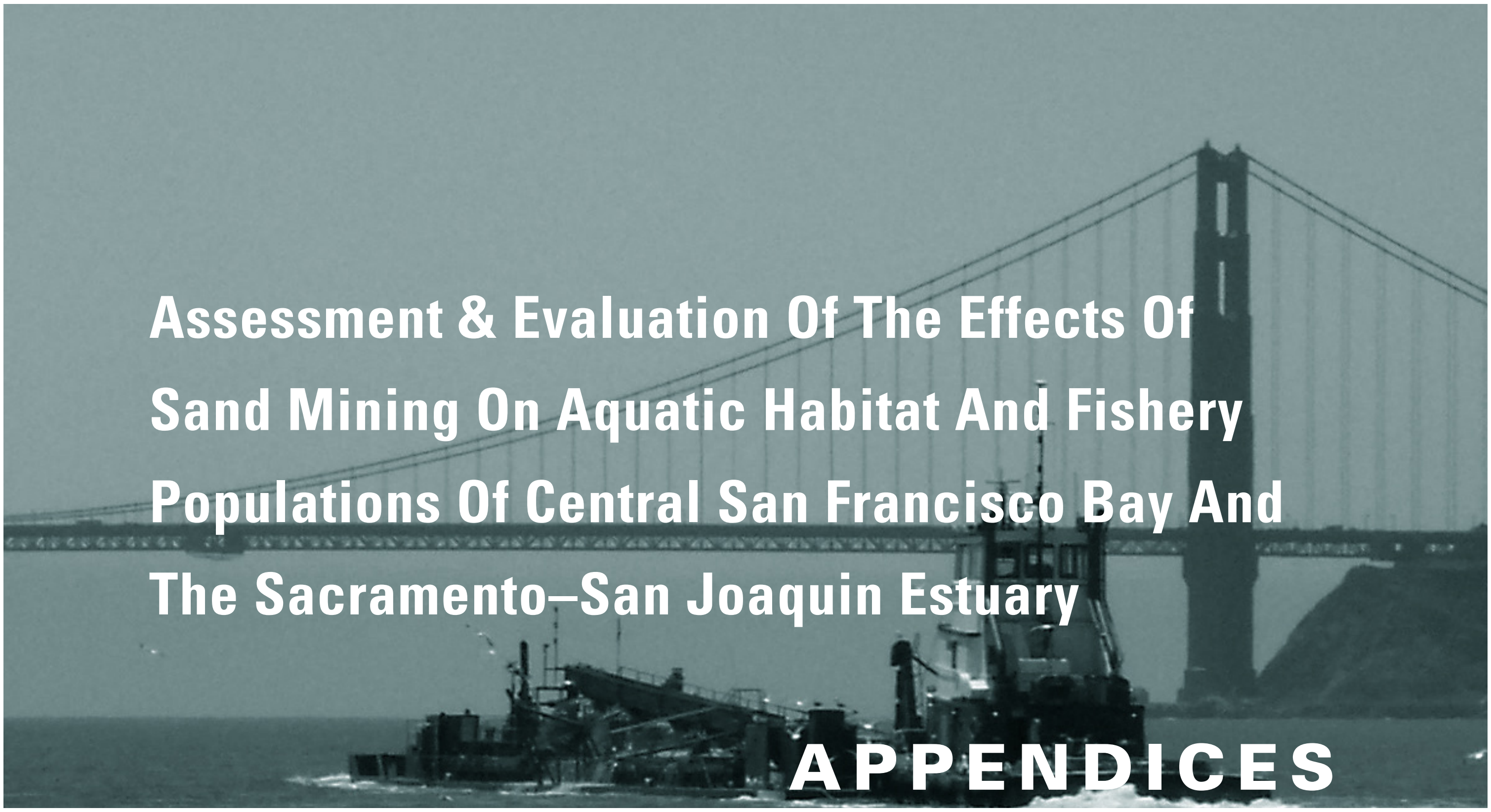

Assessment & Evaluation Of The Effects Of Sand Mining On Aquatic Habitat And Fishery Populations Of Central San Francisco Bay And The Sacramento–San Joaquin Estuary

APPENDICES

Prepared for

Hanson Aggregates Mid-Pacific, Inc.
RMC Pacific Materials, Inc.
Jerico Products, Inc./Morris Tug and Barge

Prepared by

Charles H. Hanson
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OCTOBER 2004

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Appendices

APPENDIX A

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APPENDIX B

Comments on the draft Technical Report Provided by the Independent Peer Review Panel and Agencies

Comments Received on the Draft Document Titled

"Assessment and Evaluation of the Effects of Sand Mining on Aquatic

Habitat and Fishery Populations of Central San Francisco Bay and the

Sacramento-San Joaquin Estuary"

Dated: December 2003

Peer Review Comments

Assessment & Evaluation of Sand Mining on Aquatic Habitat & Fishery Populations of Central San Francisco Bay and the Sacramento-San Joaquin Estuary.

Peer Review Report

By

R.C.Newell D.Sc.(Lond).

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GENERAL COMMENTS.

This Report is of a generally high standard both in presentation, clarity of writing and in the identification of key issues that should be taken into account in an assessment of the potential impacts of sand mining in this area. It is certainly up to International standards for the assessment of the impacts of aggregate mining on aquatic habitats and fisheries.

The following comments are intended to assist in the final revision of the Draft Report.

1. GLOSSARY OF TECHNICAL TERMS & NAMES.

1.1.The Report is one that is likely to be referred to by a relatively wide readership, many of whom will be unfamiliar with scientific terms. It would be very helpful indeed to have a Glossary of Technical Terms for reference, even if these are described in the text. One has to bear in mind that one purpose of an Environmental Assessment of this type is to make the conclusions (and the reasons behind them) transparent to a relatively wide Public readership. This may include engineers, fishermen, professional scientists and the general Public as well as administrators.

1.2. In some places in the text, the normal scientific protocol of referring to the genus and species is used when the common name of a fish (for example) first appears in the text. In other places there are long lists of common names without reference to the genus or species referred to. It will be very helpful (and avoid confusion) if there were a list of common names and scientific names of all species as either part of the Glossary of Technical Terms or as a separate list.

2. SPELLING.

2.1. The standard of English (American!) Is generally good. There are, however, some spelling errors including confusion between 'affect' and 'effect'. I refer to the places where this occurs in the detailed comments.

3. SCIENTIFIC STANDARD.

3.1. This Report is based on primary research carried out by others. It represents an important synthesis of what is known of the area, but it was surprising to discover the weakness of the data in some areas. This was the more so because sand dredging is evidently in progress and some of the uncertainties could have been reduced by some relatively short-term and simple data collection exercises, once the areas of uncertainty had been identified. In other words, unlike an area that has not yet been exploited for sand and where the Environmental Statement is entirely dependent on predicted impacts, it is possible to define the impacts in the San Francisco Bay area with some confidence.

3.2. Essentially the work recognises the importance of the habitats and the fish species that exploit the area both as adults and for breeding and nursery grounds. The study then goes on to summarise what is known of the physical characteristics of the dispersion-settlement plume associated with sand dredging. The likely impacts of loss of habitat by dredging and impacts of material mobilised by the dredging process, as well as disturbance by noise are then summarised. This review draws on site-specific and generic studies and I have no doubt that the conclusions drawn are scientifically valid.

3.3. The only part which caused me some concern was 7.12 '*Exploratory Analysis of CDFG Fishery Data*'. This database sounds detailed, and I assume has been analysed rigorously. But the section in the Report seems to be lacking in detail. I may have missed something, but statements like '*No statistically significant differences....were found..*.' (p7-91) ditto 7-92 & 7-93 are not backed up by any tables of significance, any values for probability etc. Is this citing results in another Report? The information is of considerable importance in the assessment of impacts, so needs to be presented in a summarised form. I am not surprised at the result - merely that it is key evidence for a conclusion made about sand mining in the area, and it is unreasonable to accept these as assertions unless the evidence is presented.

3.4. The final section on *'Recommendations for Additional Investigations'* does carry some risks as far as this Report is concerned. At the outset I have to say that I fully endorse the proposals made in this section - particularly relating to a much better multi-dimensional definition of the morphology of the dispersing plume under different conditions of wind and tide. There are very good methods for determining current speed, salinity, and (indirectly) suspended solids using a combination of optical and acoustic backscatter techniques. There are also very good hydrodynamic models that define the dispersion regime associated with dredging. Since this is a key part of the assessment of potential impacts, it would place the Impact Assessment on a much more secure footing if some really good acoustic backscatter profiles had been produced to demonstrate the small area of seabed and water column affected by the dredging process at different sites. I am surprised there are not some really good hydrodynamic models that predict both the suspended solids and the settlement profiles under different conditions of wind and tide. This is standard practice for most dredging applications, especially in estuarine areas where resources of high environmental sensitivity are located.

3.5. I also note (with surprise) that there appear to be no adequate records of precisely where the dredgers take on cargo on each voyage, and how much they take. There have been problems in the past in UK waters with dredgers taking cargo outside the Licenced extraction sites. With the advent of accurate GPS, and with the routine installation of systems to monitor cargo loading rates, it has been a Statutory requirement that all dredgers are fitted with a 'black box' system that records the precise position and amounts of seabed material, removed on each voyage. These data are supplied (as a Condition of the Consent) to the Statutory authorities and the data can be used to produce GIS maps showing the cargo take at each site throughout the year.

3.6. The 'Risk' that I refer to as far as the Report is concerned is that Section 9 identifies the need for much better information in a number of key areas used for the Impact Assessment. It will not take a very sharp reader to say "*If there is a need for more robust data, then this implies that the information used to predict the impacts of sand mining is not sufficiently accurate to be sure of the reliability of the predictions*". This argument will be one that I am sure a lawyer would recognise if the Report were to be discussed in the Public domain - especially by persons opposed to a further expansion of sand mining in the area.

3.7. I have to say that I agree with the predictions of the sources and likely scale of impacts of sand mining expressed here. Just to point out that you have a logical dilemma if you subsequently recognise the need for more reliable information.

4. MINOR CORRECTIONS AND COMMENTS:

EXECUTIVE SUMMARY:

Good - very clear and helpful to the reader.
P.ES-5 para 2 line 7 'the <u>effects</u> of sand mining' (not affects).
P.ES-10. Para 2. Really important admission that weakens the justification for mining. If there is '*limited information*' or in some cases '*virtually no information*' on the sand budgets, how are you going to meet the allegation that removal of sand by dredging is 'bound to lead to erosion' of the coastline or increased erosion of the source deposits'? It sounds pretty important to me that you get a proper sediment budget in place for this area.

P.1-7 2nd para last line '...that <u>affect</u> habitat quality' (not effect).
P.2-6. You may wish to know that the US Government Minerals Management Service (MMS) is currently funding a project to define 'Environmentally Friendly Dredging' strategies based on worldwide methodology. This is funded to Baird Associates of 2981 Yarmouth Greenway, Madison, WI 53711, USA. (E-mail:- tkenny@bair.com).

P2-19. Very surprised at the old technology used here! Water sampling is alright to calibrate acoustic backscatter gear - but the latter will give values for current speed and plume morphology in relation to depth and distance from the dredger. If related to a system on a moving dredger, the data can be plotted as a dispersing plume relative to the dredger in space and time. Secchi discs are 19th century - ok as a fall back, but surely an optical transmissometer is available?? These data are very important for inferences relating to the impacts of suspended solids, turbidity and settlement. You really are placing the assessment on weak ground if you cannot provide more reliable and up-to-date methodology. Then you need to make a predictive model for the plume (3-D) under different wind and tide conditions (surely someone has done this? It is basic coastal hydrography).
P.2-21. Para 3 line 1. '<u>dependent</u>' (not dependant).
P.2-24. Para 1. The inherent drawbacks of having sediment data for only one depth become apparent! I really do urge some better measurements. It would only take a few days with the right gear.
P.2.29 4th line from bottom. 'Biological <u>effects'</u> (not affects).

P.5-1 para 3 line 5. '*Zooplankton Pacific herring*' is a non-seq. I think it should be deleted.
P.5.3. 1st line. This should be carbon <u>dioxide</u> (not monoxide).
Note: This section uses the normal scientific method of the common name followed by the scientific one. It would be helpful if

this were adopted elsewhere in the text and that all such names were in a glossary at the end.

P.6-13. Para 2 line 8. 'Indirect effects' (not affects).

P.7-2 last para line 3. Delete bracket after 'adverse effects:'
P.7-9 line 2. Capital W for Ward.
P.7-15 last para line 1. 'effects of the overflow plume' (not affects)
GOOD sections on effects of suspended solids on fish and inverts.
GOOD Conclusions section - these are very helpful here and in the other sections of this long Report.
7-36. 'No toxicity testing data is (are!) Available.......for Central or Suisan bays...' Any reason for this? Do you think that the results for the other sand dredge sites will be applicable to this area? If so, it may be worth saying that although no data are available, it is unlikely that the results would be different from those reported for outflow conditions at the other sites.
P.7-37 para 3 line 3. Suggest '...results in potential entrainment mortality for fish...'
P.7-41 para 2 line 3. This should be '...also estimated mortality rates for entrained crabs' (not entrainment rates).
P.7-42. Para 2 line 6. Should be 'Bay shrimp...' (Not By)
P. 7-43. Para 1 line 10 . A bit of a daft statistic! Why not just say '...a high natural mortality rate (>99.9%).
P.7-50. Para 3 line 3. Suggest delete 'In recent years there has been an increased......and fish species (Popper 2003).' since this repeats the earlier sentence.
P. 7-50 Para 4 line 6 'affect survival' (not effect).
GOOD section on noise from dredging.
P.7-60. Para 1 line 3 'potentially affected' (not effected)
P.7-60. Para 1 line 4 'these effects' (not affects!!!). You will be getting me confused soon!
P.7-65. Para 2. I think that the sentence beginning '*However, the appearance and composition of most communities do not change over time, as organisms replace each other in continual self-perpetuation*' should be deleted. It is naive ecology because although benthic communities can be quite stable in some deeper water habitats, they can also undergo quite abrupt (and unexpected) changes in community composition. It also contradicts your paragraph 2 (page 7-74) where you correctly recognise that '*Complex communities can vary over time, even without disturbance.....*'
P.7-74 Para 1 line 3. This should be 'southeastern' England (not southeaster)
P.7-75 Para 2 Line 5. 'Indirect effects to sediment' (not affects).
P.7-77 Para 3 line 6. This should be '...as moderate to high' (not too).
P.7-78 All the paragraphs with common names of fish ought to have the genus and species in parentheses. Ditto P. 7-79 etc.
P.7-80. Para 2 line 7. '...localised and temporary effect...' (Not affect).
P.7-81-82. Genus and species names of the fish in parentheses.
P.7-83. Para 3 line 7. '...quantitative data are available...' (Not is) data is a plural noun.
P.7-83. 5 lines from bottom. 'Side-scan sonar surveys' more usual than 'side-scanning'.
P.7-89. Bottom line. 'Potential adverse effects of sand mining...' (Not affects).
P.7-91-93. Where are the statistical analyses referred to? Either need a table summarising the evidence or a reference to where it could be looked up. Basically the Summary recognises that there is an '*absence of samples collected from representative areas*...' That is, even if you did show statistical differences between sites, is this attributable to sand mining or is it due to other habitat differences between the sample sites. This section seems weak to me. Are you happy and confident with it? Do you think that the results can be interpreted well enough to warrant inclusion?
P.7-97. Para 3 line 1. ' Direct and indirect effects of sand mining...' (Not affects).
P.7-97 Para 3 line 9 ' The potential of sand...' (Not affects).

P.8-2. Line 1 '...direct and indirect effects of sand mining...' (Not affects).
P.8-9. Para 1 line 5. '...localised effects...' (Not affects).

P.9.2. Para 3 line 1. Surely information on the occurrence of navigational conflicts or collisions would need to be reported as a matter of maritime law? You suggest here that is 'might be a good idea'!!
P.9-2. Data logging on board ought to be through a black box system that records both the pumping and loading data as well as the position of the vessel. This is required as part of the Licence conditions in UK waters.

P.9-12-13. All this requirement for better plume definition is a 'must' if you are going to convince others that you have a reliable basis to predict important components of potential impact.
P.9-14. Para 2 line 8. '..limit the potential effects...' (Not affects).
Note: I have commented earlier of the MMS study on environmentally friendly dredging. It might be worthwhile a cross-reference to progress that might be made in reducing the impacts of sand and gravel dredging.
P.9-14 5th line from bottom. I get a little concerned with statements like '...*would provide an improved scientific basis for the conclusion that sound associated with sand mining is not a significant factor affecting the Bay-Delta estuary fish or macroinvertebrate communities*.' The reason that I get concerned is that you have written what I considered to be a rational explanation of what the sound frequency and level is coming from a dredger in relation to distance and ambient noise. You then reviewed in some detail the thresholds for damage and avoidance behaviour in fish. At that point I felt reassured as a reader that the levels were below that at which damage would occur, but were within the range that most fish would take avoidance. This is fine. But now it seems that you are not so sure that the scientific basis for your assessment is watertight. This seems dangerous to me. Either we accept what the scientific literature tells us and make the assessment, or we give a 'health warning' to the assessments and say that we really need much better site-specific data. But we cannot have it both ways without seriously prejudicing your conclusions.

P.9-15. The same problem arises regarding entrainment. I had settled down to your assessment (and calculations) of entrainment risk. Then we find the statement '*In the absence of information on the vulnerability of various species to entrainment during sand mining in the estuary, the potential magnitude of adverse effects on population dynamics of the species cannot be determined with confidence*'. So where exactly does this leave us regarding the reliability of your Impact Assessment section? If I were opposed to sand mining, I would quote these statements back at you to suggest that the basis of the impact assessments is fundamentally flawed. I emphasise that I think your assessment section is good - just that you do seem to be greatly weakening your own assessment by back-tracking on the reliability of the data upon which your assessment is based.
P.9-16. Para 1 next to last line. This should be '...may be over or under estimated...' (Delete 'in').
P.9-18. Again we have a statement '*Detailed site-specific information on benthic macroinvertebrate recovery is not available, however*,...'. The reader might well ask why this information is not available bearing in mind that sand dredging has taken place for many years, and there must be areas where dredging has ceased for know periods to test the hypothesis about the rate of recovery.
P.9-19. Track-log data ought to be recommended as a condition of the Licence. Unless you know the amounts removed and where from, you will never be able to understand the impacts on the seabed morphology, the sediment budget or the extent of habitat loss.
P.9-19. Para 4. There are quite a few studies on factors affecting benthic recovery which would be a useful reference point for work at these San Francisco Bay sites. Specially new ideas about ways in which impacts on biodiversity can be detected without the need for 'control' sites or baseline (pre-dredge) conditions.
P.9-20 Bottom paragraph. This last paragraph really summarises the problem! As an informed reader, I am not now sure whether your assessment of small impact of sand mining is correct or not. It seems to the reader that you gave an assured review and made the appropriate conclusions, and then in the last chapter you have back-tracked on the reliability of the data and the reliability of the inferences that can be placed on them.

5. CONCLUSIONS.

I liked this work. It is (in my view) rather long and repetitive in places. I could follow the logic of the layout and I think that the inferences were valid based on the literature summarised in some detail in the Report. The conclusions have no surprises compared with impact assessments for other sand and gravel dredging projects with which I am familiar in European coastal waters. However I wonder if the author of Chapter 9 was the same as that for the other sections? It seems to be an altogether more tentative assessment, and one is left with a feeling of uncertainty about how robust the authors feel the impact assessment to be.

If there is an element of doubt creeping in, then there are certainly some relatively simple site-specific studies that ought to be carried out. One of these is certainly proper definition of the sedimentation plume using up-to-date methodology with an aim of a 3-D definition of the plume under differing wind and tidal conditions, and the production of a 3-D plume model for predictive purposes using conventional software.

R.C.Newell
22.12.03

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March 11, 2004

Chuck Hanson, Ph.D.
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March 3, 2004

Dear Chuck:

Here are my comments regarding the environmental report, "Assessment and Evaluation of the Effects of Sand Mining on Aquatic Habitat and Fishery Populations of Central San Francisco Bay and the Sacramento-San Joaquin Estuary". I will be providing general comments regarding the information presented, a brief list of common inconsistencies encountered, and suggested specific changes to the text on a page-by-page, line-by-line basis. My apologies for these lengthy specific comments, but prior to retiring, I spent a number of years as an editor for some of the Department of Fish and Game's marine scientific and technical periodicals and reports. As a result, my reading eye tends to pick up problems with spelling, punctuation, and especially with consistency in word usage, formatting, etc. I am confident that many of these problems have already been addressed during your on-going, in-house review, but I include them, I believe, with your approval .

GENERAL COMMENTS

The document appears to have discussed all the principal environmental conditions surrounding sand mining in the San Francisco Bay-Delta estuary. In my view, it is a thorough, up-to-date, and comprehensive review and evaluation of the available literature, data, and anecdotal information regarding this subject. There are some segments of the document, however, that could be tightened up in my opinion, particularly if the sand mining industry moves forward with its applications to increase the amount of material it removes from the Bay and Delta. They are as follows:

- Accretion and Depletion - Although the report draws the conclusion that there is no constant evidence that sand mining has contributed to sediment depletion on a regional scale (P. ES-10, 6-10), there are a number of findings that give rise to concerns that sub-regions of Central San Francisco Bay may be impacted in measurable, if not significant ways.

  1. Results of these analyses suggest that depletion within a number of these areas may have resulted in an increase in water depth from approximately 4 to 6 feet. (P. 4-25, 30)
  2. Overall, there was a net depletion of approximately 2.6 million cubic yards of sediment in Central Bay from January 1999 through July 2002. (Table 4-5 and P. 4-29, 6-11)
  3. "Pock" areas at Point Knox Shoal and Presidio Shoal could be considered artificial erosion due to sand mining activities. (P. 4-33, 6-9)
  4. Virtually no information is available on sand recruitment or replenishment within areas of either Suisun Bay or Central Bay where sand mining occurs. (P. 4-61)
  5. Mining is proceeding into older and deeper deposits. (P. 6-9)
  6. Table 7-9 (a and b) shows considerable deepening in areas of Central Bay well beyond the normal 4 to 6 foot range.

  As a result, I concur with the following recommendations made in the report:

  1. Sand mining monitoring should continue to document the location and characteristics of individual sand mining events over a 2 to 3 year period. (P. 9-2)

2. Improvements should be made to bathymetric surveys to assess current and future sand mining, as well as developing a program to determine the accuracy and precision of the depletion and accretion analysis. (P. 9-4, 5)

3. Surveys need to focus more on areas where sand mining occurs, have protocols that that include more intense bathymetry, and designs that provide periodic regularity. (P. 9-6)

4. A sediment budget needs to be prepared for those areas mined and influenced by mining that would identify areas where sand mining could take place without resource-related problems, as well as areas where long-term sand harvest could not be supported. (P. 9-8, 9)

5. Appropriate reference sites should be identified. (P. 9-10)

- Plume - The document indicates that there is no significant behavioral avoidance or changes in distribution within localized areas from the overflow plume and that any response is localized, intermittent, and temporary. However, there are several statements or issues that lead to some concern or uncertainty; they are:

1. There are short-term, localized impacts to some sensitive fish species such as northern anchovy and Pacific herring in Central Bay. (P. 7-26, 83, 84)

2. No mention is made of herring schools holding in deep water waiting to spawn that could be disrupted by plume overflow or other sand mining activities. (P. 7-96)

3. Unknown cumulative effects on predator-prey relationships, as well as growth and survival, occur when sand mining is combined with dredged material disposal. (ES-17)

4. Reduced angling success for game fish (e.g., halibut) is reported. (P. 7-81)

5. There is uncertainty about the foraging success of larval and juvenile striped bass in Suisun Bay. (P. 7-81)

As a result, I concur with recommendations regarding monitoring the overflow plume, particularly with respect to subsurface discharge, and to study suspended sediment concentrations during sand mining in Central Bay and in the navigational channels at Middle Ground Shoal and in Suisun Bay. (P. 9-12, 13)

- Habitat - Although subtidal habitats directly affected by sand mining are generally deepwater benthic habitats, and the assessment has not identified significant individual environmental effects on habitat quality, availability, or usage, several important issues are identified in the document. (P. ES-13) They are:

1. During the scope of the study, sand mining occurred in shallow water, sensitive areas (e.g., rearing and foraging habitat). (P. E-18)

2. Table 7-49 (a and b) shows some major increases in Central Bay water depth at sand mining locations.

I concur with the recommendations regarding the identification of sensitive areas, as well as those areas that may be designated as refuges to preserve sensitive, subtidal aquatic habitat. In addition, I also support studies into the physical changes made to the benthos and the duration of sand replacement. (P. 9-17,18)

- Fish, Macroinvertebrates, and Fisheries - Several major potential impacts from sand mining were discussed in detail in the document ; they were entrainment, opportunistic and invasive species, changes in abundance, and user conflicts.

1. Sand mining will result in entrainment of fish eggs and larvae (e.g., halibut and Pacific herring), enough juveniles to represent 0.7% of the Dungeness crab commercial harvest, and 15 to 20% of the commercial bay shrimp catch. (P. 7-26, 44, 47, 82, 86)

2. There are often changes in species composition and abundance of benthic invertebrates as a result of sand mining. Only opportunistic species, including invasive species, are found at the dredging site. ((P. ES-17, 7-74)

3. It is difficult to make statistical comparisons on fish abundance and the results of the CDF&G fishery data are often inconclusive, although information on Central Bay suggests a pattern of reduced abundance of shiners, gobies, halibut, and anchovy. (P. 7-83, 91, 92, 93, 94)

4. Although the report indicates that sand mining activity is not expected to result in significant reduction in angling success, there is a strongly suspected decrease resulting from baitfish response to increased suspended particulate matter. Additionally, it is wrong to suggest that Pacific herring fishermen can move away from sand mining activity; they are able to fish only at those locations where spawning activity is taking place. I would also express a concern not mentioned in the report that increased suspended particulate matter in proximity to developing attached herring eggs could be harmful. (P. 7-95, 97, 98)

As a result of these issues, I fully support the following recommendations regarding:

1. Use of side-scan sonar for studying fish distribution and abundance in Central Bay before, during, and after sand mining events. (P. 9-14)

2. Evaluation of new technologies in marine mining equipment. (P. 9-14)

3. Conducting a study on the entrainment of fish and macroinvertebrates in Central San Francisco Bay. (P. 9-15)

4. Comparing the benthic invertebrate community between sand mining areas and reference sites.

Additionally, I would recommend consultation with CDF&G Marine Region on Harbor Drive in Belmont for some insights and more accurate information on Pacific herring and other commercial/recreational fisheries in Central San Francisco Bay.

- Cumulative Effects - It is acknowledged that potential incremental effects, though not significant individually, have the potential to contribute to cumulative effects. The concern that needs to be addressed is when do these cumulative effects become significant.

Inconsistencies

The following is a brief list of some of the more common inconsistencies that I encountered and a rationale for my suggested changes.

- Use of the term "Central Bay" as opposed to "the Central Bay" -- "Central Bay" was the most commonly used; therefore, I point out when "the Central Bay" is used.

- Most citations do not include a comma between the author(s) and the year published, therefore, I point out when that is not the case. Additionally, the document most often puts a comma after "*et al*", however, there are many instances when this does not take place.

- There is not a uniform approach to expressing numbers, i.e., using numerals or writing out the number. As a result, I have applied the approach that all numbers 10 or more are expressed as numerals except when they begin a sentence. Numbers nine or less are written out except when they precede units of volume, length, time, weight, etc., (e.g., 2 ml, 5 mm, 6 hr, 8 mg) or are part of a series.

- In many instances, a comma is left out of numbers 1,000 or more, and at other times it is inserted correctly. For example, P. 2-28, Ln. 21., "5000 to 15,000 gpm". This inconsistency happened too frequently for me to identify its occurrences.

- The use of commas is not consistent, particularly with respect to prepositional phrases and independent clauses leading off sentences. I have occasionally identified locations where this has occurred. Additionally, there are numerous complex and compound sentences in which additional commas would facilitate the reading of this document. I would suggest a review by a professional proof reader at some point before final publication.

- There is not a consistent use of "hyphens" versus the words "to" and "through" when expressing a range of numerical units. For example, P. ES-8, Ln. 15. "500-1000 meters" and Ln. 21 "5 to 30 mg/l". I would suggest using "to" or "through" when possible (tables would be an appropriate exception) for greater accuracy. I have not singled out all the times that this has occurred in the text.

- Sacramento splittail is most often referred to as just splittail, although occasionally as Sacramento splittail. CDF&G data (Appendix G) use splittail in their tables. Appendix G tables also do not capitalize the "c" in chinook salmon, although it is capitalized throughout most of the text. I have made no suggested changes, but you may wish to address these differences in any final report.

- Many of the tables are not uniform in the various headings used, particularly with respect to capitalization. This even occurs within some tables, as well as between tables. Where I have recognized this problem, I have indicated so in my comments. Additionally, many of the figures need improved reproduction, although I recognize that this document is still in the draft stage.

- The document is inconsistent with regard to the use of the symbol for percentage (%) and the term "percent." For example, P. 7-14, Ln. 12 reads "40 percent" and P. 7-19, Ln. 10 reads "5 percent"; whereas on O. 7-21. Lns. 31 and 33 read "50%" and "10%," respectively.

Specific Comments

Table of Contents:

6.4.1 Reads …Physical Environmental Resulting…; should read …Physical Environment Resulting….

6.4.2 Same as above.

List of Figures:

P. 6. Figure 4-48. Reads…6 mining events; should read…six mining events.
P. 6. Figure 4-52. Reads …the Central Bay; should read …Central Bay.
P. 7. Figure 4-60. Reads…tidal Flows; should read …tidal flows.
P. 9. Figure 4-103. Reads …MEC(1993); should read…MEC (1993).
P. 9. Figure 4-104. Reads …(MEC, 1993); should read …(MEC 1993).
P. 9. Figure 4-105. Same as above.
P. 10. Figure 4-114. Same as above.
P.11. Figure 5-6.Reads …Baxter *et al. 1999)*; should read…Baxter *et al*. 1999.
P. 12. Figure 7-9.Reads ….Auld and Schubel); should read …Auld and Schubel 1978).

List of Tables:

P. 16. Table 1.1. Reads …State Land Commission; should read …State Lands Commission.
P. 16. Table 2-14.Reads …plumes at a 5 foot; should read …plumes at 5 foot.
P. 17. Table 4-3. Reads …State Land Commission; should read …State Lands Commission".
P. 18. Tables 5.5 through 5.11.Reads …Otter Trawl, Midwater Trawl, and Plankton Net; should read …otter trawl, midwater trawl, and plankton net.
P. 19. Table 5-12 through 5-16.Same as above.

Executive Summary:

P. ES-1. Ln. 19. The Magnussen-Stevens Act should be cited here regarding Essential Fish Habitat.
P. ES-1. Ln. 35. Reads …However,, (note double comma); should read …However,.
P. ES-5. Ln. 1. Reads …Carquinez Straits; should read …Carquinez Strait.
P. ES-5. Ln. 7. I believe the initials SLC and BCDC are being used before the full name of the agency and the corresponding initials have been used (see P. ES-6).
P. ES-5. Ln. 12. Reads …Carquinez Straight; should read …Carquinez Strait.
P. ES-5. Ln. 21. Reads ….affects; should read …effects.
P. ES-6. Ln. 9. Reads …effect; should read …affect.
P. ES-8. Ln. 29. Reads …hour period the; should read …hour period, the.
P. ES-9. Ln. 2. Reads …as part this; should read…as part of this.
P. ES-11. Ln. 22. Reads …estuary has shown; should read …estuary have shown.
P. ES-11. Lns. 35-6. Reads …resulting in the upwelling; should read … resulting in upwelling.
P. ES-15. Ln. 5. Reads …changes land practices; should read …changes in land practices.
P. ES-15. Ln. 26. Reads …cumulatively, reduced; should read …cumulatively reduced.

Chapter 1:

P. 1-2. Ln. 37. Reads …community inhabiting; should read …communities inhabiting.
P. 1-4. Ln. 3. Reads …to with the; should read …to the.
P. 1-4. Ln. 26. Reads …that effect habitat; should read …that affect habitat.
Table 1-1. Lns 1&2. Reads …State Land Commission; should read …State Lands Commission.

Chapter 2:

P. 2-1. Ln. 8. Reads …evaluating affects of; should read …evaluating effects of.
P. 2-2. ln. 2. Reads …sand in the case of; should read …in the case of.
P. 2-2. Ln. 3. You may wish to consider starting a new sentence with "sand from the Bay-Delta".
P. 2-4. Lns. 25, 27, 31. The word tug is italicized and capitalized; this is not consistent with the use of the word throughout the rest of the paragraph.
P. 2-6. Ln. 11. Is the following an accurate statement? …"slowly lowered 15 to 20 feet into the sand substrate." See P. 2-7., Ln. 9

and P. 2-8., Lns. 28-30.
P. 2-22. Ln. 38. Reads …effect settling; should read …affect settling.
P. 2-23. Lns. 38-39. Reads …three months; should read …3 months.
P. 2-28. Ln. 18. Reads …During mining water; should read …During mining, water.
Table 2-1. Ln. 8. Reads …State Land lease; should read …State Lands lease.
Table 2-9. Ln. 2. Reads …the one-year; should read …the 1-year.

Chapter 3:

No comment

Chapter 4:

P. 4-2. Ln. 2. Reads …sentiment; should read …sediment.
P. 4-3. Ln. 29. Reads …a different scales; should read …a different scale.
P. 4-7. Ln. 3. Reads …south bay; should read …South Bay.
P. 4-9. Ln. 4. Reads …the Central Bay…; should read …Central Bay.
P. 4-10. Ln. 32. Reads …at Golden Gate; should read …Golden Gate.
P. 4-10. Ln. 39. Same as previous page.
P. 4-11. Lns. 18, 20, 24, 32. "San Francisco bar" is used twice and "San Francisco Bar" is used twice. Which is correct usage for this report?
P. 4-13. Lns. 2, 19. Reads …the "Delta"; in succeeding pages it reads the "delta."
P. 4-18. Lns. 20, 21. Reads …of Golden Gate; should read …the Golden gate.
P. 4-28. Ln. 12. Reads …of 6 "sand areas" (Table 4-3)." ; should read …of six "sand areas" (Table 4-3).
P. 4-29. Ln. 21. Reads…there was a net accretions; should read …"there were net accretions.
P. 4-29. Ln. 37. Reads …accretions and deletions; should read accretions and depletions.
P. 4-30. Ln. 14. Reads …and deletions; should read…and depletions.
P. 4-33. Ln. 22. Reads …as three miles from shore, in waters less then ten feet deep.; should read …as 3 miles from shore, in waters less than 10 feet deep.
P. 4-37. Ln. 4. Reads …sentiment; should read …sediment.
P. 4-37. Ln. 16. Reads… limited to of water depth; should read …limited to a water depth of.
P. 4-38. Ln. 31. Reads …has a significant effect; should read …have a significant effect.
P. 4-42. Ln. 26. Reads …are influence by; should read …are influenced by.
P. 4-45. Ln. 3. Reads …nutrient-deficiency; should read …nutrient-deficient.
P. 4-46. Ln. 32. Reads …localized decreased in; should read …localized decreases in.
P. 4-53. Ln. 9. Reads …for three months; should read …for 3 months.
P. 4-54. Ln. 21. Reads …1993 – 2000. This data was averaged; should read …1993 and 2000. These data were averaged.
P. 4-55. Ln. 6. Reads …presented an analyzed; should read …presented and analyzed.
P. 4-56. Ln. 3. Reads …obtained from Department; should read …obtained from the Department.
P. 4-57. Lns. 26,27. Reads …This data provides; should read …These data provide.
P. 4-58. Ln. 1. Reads …in the Racoon Strait; should read …in Racoon Strait.
P. 4-58. Ln. 24. Reads …at ten foot; should read …at 10-foot.
P. 4-59. Lns 12, 15, 22, 26. The word "re-suspension" is spelled with the hyphen three times and once without. It is spelled without the hyphen again on P. 4-61, Ln. 14 and again on P. 4-62, Ln. 38. Spell-check prefers the hyphen, but both are acceptable in my experience. You should select one.
P. 4-62. Ln. 17. Reads …mining operation did; should read … mining operations did.
P. 4-62. Ln. 32. Reads …estuary has shown; should read …estuary have shown.
P. 4-62. Ln. 39. Reads …Within Central Bay turbidity; should read …Within Central Bay, turbidity.

P. 4-63. Ln. 3. Reads …the upwelling within; should read …upwelling within.
Figure 4-4. Ln. 1. Reads …(eastern Zone); should read …(eastern zone).
Figure 4-7. Lns. 3, 4. Closing parenthesis needed for sentence ending "Lands End (LE)."
Figure 4-10. Ln. 4. Reads…Parsons et al, 2002; should read …Parsons *et al*., 2002.

Figures 4-12a, b.	"Tiburon Peninsula" is incomplete on these two maps.
Figure 4-48. Ln. 1.	Reads …having 6 or fewer; should read …having six or fewer.
Figure 4-105.	Heading in box that is middle right should be in bold type. Heading in box lower right appears to be in a smaller type.
Figure 4-116. Ln. 1.	Reads …moves passed; should read …moves past.
Table 4-3. Ln. 1.	Reads …State Land Commission; should read "State Lands Commission.
Table 4-13. Ln. 3.	Period needed at the end of the sentence that begins with the first asterisk.
Table 4-17. Ln. 1.	Reads …"mining over flow plume"… should read "mining overflow plume"….

Chapter 5:

P. 5-3. Ln. 13.	Reads…common pickle weed, and California cord grass; should read …common pickleweed, and California cordgrass. Additionally, the scientific names of these salt tolerant plants should probably be referenced here.
P. 5-4. Ln. 28.	Reads …position of the base; should read …position at the base.
P. 5.5. Ln. 20.	Reads …the Central Bay; should read …Central Bay.
P. 5.5. Ln. 35.	Reads …*Coscinodiscus spp. and Cyclotells spp*.; should read …"*Coscinodiscus* spp. and *Cyclotella* spp.
P. 5-6. Ln. 13.	Reads …Zooplankton include small; should read …Zooplankton includes small.
P. 5-7. Ln. 41.	Reads …numbers to low; should read …numbers too low.
P. 5-8. Ln. 2.	Reads …Oyster populations; should read …These oyster populations.
P. 5-9. Ln. 8.	Reads …(*Crangon spp.*); should read …(*Crangon* spp.).
P. 5-9. Ln. 13.	I would suggest researching this comment more thoroughly. Juveniles have been shown to be the most predominant crab stage within the Bay-Delta estuary.
P. 5-10. Ln. 20.	Reads …staghorn sculpin; should read …Pacific staghornsculpin. Additionally, the scientific name that is mentioned on P. 5-11, Ln 12 should be cited here when the common name is first mentioned.
P. 5-12. Ln. 5.	Reads …National Marine Fisheries Service; should read …NOAA Fisheries.
P. 5-16. Ln. 8.	Reads …the Central Bay; should read …Central Bay….
P. 5-17. Ln. 7.	Are any of the Chinook salmon identified part of the listed winter-run population.?
P. 5-17. Ln. 12.	Reads …adverse affect associated; should read …adverse effects associated.
P. 5-17. Lns. 27, 28.	Write out the numbers "5" and "3", respectively.
P. 5-18. Ln. 6.	Reads …zone provides habitat; should read …zone provide habitat.
P. 5-18. Ln. 32.	Reads …float for drift; should read …float or drift.
P. 5-21. Ln. 12.	Reads …*al., 1999* ; should read…*al.,* 1999).
P. 5-22. Ln. 16.	Reads …(*Raja binoculate*); should read …(*Raja binoculata*).
P. 5-27. Ln. 15.	Reads …for one year; should read …for 1 year.
P. 5-27. Ln. 21.	Reads …anglers; should read …fishers.
P. 5-27. Ln. 23.	Reads …last of species of ; should read …last of species.
Figure 5-18.	Are the "Graceful" and "Pacific" rock crabs the correct common names? They used to be called the slender and brown rock crabs, respectively.

Chapter 6:

P. 6-6. Ln. 5.	Reads …per year would; should read …per year, would.
P. 6-6. Ln. 25.	Reads …approximately eleven years; should read …approximately 11 years.
P. 6-9. Lns. 37,38.	Reads …about seventy years and …for over fifty years; should read …about 70 years and …for over 50 years.
P. 6-13. Lns. 6,7.	Incomplete sentence beginning with "Since" and ending with "channel."

Chapter 7:

P. 7-5. Ln. 16.	Reads …and barge utilized; should read …and barges utilized.
P. 7-6. Ln. 38.	Reads …turbidity, could occur; should read …turbidity could occur.
P. 7-7. Ln. 13.	Reads …within the Central Bay; should read …within Central Bay.
P. 7-8. Ln. 36.	Reads …so then adult; should read …so than adult.
P. 7-9. Ln. 35.	Reads …The principal of; should read …The principle of.
P. 7-11. Ln. 36.	Reads …Species varies among; should read …species vary among.
P. 7-12. Ln. 4.	Reads …clogging,; should read …clogging.. (Note period instead of comma)
P. 7-12. Ln. 22.	Reads …concentration then 1,000 mg/l; should read … concentration than 1,000 mg/l.
P. 7-12. Ln. 42.	Reads …then their own; should read …than their own.
P. 7-14. Ln. 31.	Reads … Clarke, 2001; should read …Clarke 2001.
P. 7-14. Ln. 34.	Same as above.
P. 7-15. Ln. 3.	Reads …three year study; should read …3-year study.
P. 7-15. Ln. 35.	Reads …potential affects of; should read …potential effects of.
P. 7-16. Ln. 14.	Reads …sediment affects on; should read …sediment effects on.
P. 7-16. Ln. 21.	Reads…a through coating; should read …a thorough coating.
P. 7-19. Ln. 31.	Are we talking fall run only?
P. 7-20. Ln. 26.	Reads …and staghorn sculpin ; should read …and Pacific staghorn sculpin.
P. 7-22. Ln. 7.	Reads …occur exposure; should read …occur at exposure.
P. 7-23. Ln. 17.	Reads …was compiled ; should read …were compiled.
P. 7-25. Ln. 40.	Close the parentheses that were started on the previous line for this sentence.
P. 7-26. Ln. 29.	What type of "sculpin" are we citing here?
P. 7-27. Ln. 7.	Reads …below level; should read …below a level.
P. 7-27. Ln. 20.	Reads …Clark, 1968; should read …"Clark 1968.
P. 7-27. Ln. 30.	Reads …higher then; should read … higher than.
P. 7-32. Ln. 14.	Reads…for three months; should read …for 3 months.
P. 7-32. Ln. 24.	Reads …one meter and two meters"…; should read …1meter and 2 meters …, respectively.
P. 7-33. Ln. 28.	Reads …between 1993-2000. This data was averaged; should read …between 1993 and 2000. These data were averaged.
P. 7-34. Ln. 5.	Reads …In all cases the; should read …In all cases, the.
P. 7-34. Ln. 38.	Reads …and if found; should read …and, if found.
P. 7-36. Ln. 38.	Reads …re-suspension; should read …resuspension.
P. 7-37. Ln. 30.	Reads …shell fish; should read …shellfish.
P. 7-38. Ln. 12.	Reads …Puget sound; should read …Puget Sound.
P. 7-38. Ln. 19.	Reads …foundinfluenced; should read …found influenced.
P. 7-39. Ln. 1.	Reads …shell fish; should read …shellfish.
P. 7-39. Ln. 35.	Reads …410 cy. of; should read …410 cy of.
P. 7-40. Ln. 7.	Reads …1988 a collection; should read …1988, a collection.
P. 7-40. Ln. 8.	Reads …In this way crab; should read …In this way, crab.
P. 7-41. Ln. 35.	Reads …(i.e. degree; should read …(i.e., degree.
P. 7-42. Ln. 17.	Reads …sand bay; should read …bay shrimp.
P. 7-42. Ln. 30.	Reads …Clarke, 1998; should read …Clarke 1998.
P. 7-42. Ln. 37.	Reads …the crab present; should read …the shrimp present.
P. 7-45. Ln. 12.	Reads …per 1000 cubic yard; should read …per 1,000 cubic yard.
P. 7-45. Ln. 16.	Reads …regression it was; should read …regression, it was.
P. 7-45. Ln. 20.	Reads …(1998) a regression; should read …(1998), a regression.

P. 7-46. Ln. 10.	Reads …in 1000 cubic; should read …in 1,000 cubic.
P. 7-46. Ln. 26.	Reads …Suisun Bay no individuals; should read …Suisun Bay, no individuals.
P. 7-46. Ln. 37.	Reads …(CDFG, 1999); should read …(CDFG 1999).
P. 7-46. Ln. 38.	Reads …landings an estimate; should read …landings, an estimate.
P. 7-47. Ln. 15.	Reads …summarizes; should read …summarize.
P. 7-47. Ln. 15.	Reads …at the four; should read …at the four locations.
P. 7-47. Ln. 31.	Reads …pound then; should read …pound, then.
P. 7-47. Ln. 37.	Reads …the Central Bay; should read …Central Bay.
P. 7-48. Ln. 3.	Reads …pacific; should read …Pacific.
P. 7-48. Ln. 18.	Reads …estimates then used; should read …estimates used.
P. 7-48. Ln. 19.	Reads …of this; should read …of these.
P. 7-48. Ln. 30.	Reads …month in; should read …month.
P. 7-48. Ln. 31.	Reads …and train; should read …entrained.
P. 7-48. Ln. 35, 36.	Reads …one-year; should read …1-year.
P. 7-48. Ln. 37.	Reads …estuary entrainment; should read …estuary, entrainment.
P. 7-49. Ln. 7.	Reads …entrainment equivalent; should read …entrainment, equivalent.
P. 7-49. Ln. 14.	Reads …a fish eggs will; should read …a fish egg will.
P. 7-49. Ln. 15.	Reads …probability of a larger; should read …probability a larger.
P. 7-49. Ln. 31.	Reads …pacific herring; should read …Pacific herring.
P. 7-49. Ln. 42,	Reads …results it was; should read …results, it was.
P. 7-50. Ln. 4.	Reads … Ichthyoplankton; should read …ichthyoplankton.
P. 7-50. Ln. 11.	Reads …activity underwater noise; should read …activity, underwater noise.
P. 7-51. Ln. 6.	Reads …this data; should read …these data.
P. 7-52. Ln. 24.	Reads …study ambient; should read …study, ambient.
P. 7-54. Ln. 11.	Reads …larger then; should read …larger than.
P. 7-56. Ln. 36.	Reads …Hanson, 1994; should read …Hanson 1994.
P. 7-57. Ln. 11.	Reads …fish to; should read …fish.
P. 7-57. Ln. 15.	Please review the construction of the sentence beginning with “As Figure 7-39 demonstrates”… It is most confusing to me.
P. 7-57. Ln. 37.	Reads …their six week runs; should read …their 6-week runs.
P. 7-57. Ln. 39.	Reads …72% of; should read …Seventy-two percent.
P. 7-58. Ln. 19.	Please review this sentence; I believe it is incomplete.
P. 7-58. Ln. 30.	Reads …Johnstone, 1978; should read …Johnstone 1978.
P. 7-59. Ln. 13.	Reads …as two hours; should read …as 2 hours.
P. 7-60. Ln. 3.	Reads …potentially effected; should read …potentially affected.
P. 7-60. Ln. 4.	Reads …these affects; should read …these effects.
P. 7-60. Ln. 10.	Reads …Yan 2002b), While on was; should read …Yan 2002b), while one was.
P. 7-60. Ln. 26.	Reads …frequencies, they are likely ; should read …frequencies, are likely.
P. 7-63. Ln. 3.	Reads …pacific herring; should read …Pacific herring.
P. 7-63. Ln. 42.	Reads …Hanson, 1994; should read …Hanson 1994.
P. 7-66. Ln. 34.	Reads …abundance is also; should read …abundance are also.
P. 7-68. Ln. 19.	Reads …the Central Bay; should read …Central Bay.
P. 7-70. Ln. 26.	Reads …for three years; should read …for 3 years.
P. 7-70. Ln. 31.	Reads …competition, a lower productivity and longer growth rates, and (5) a negative; should read …competition, lower productivity and longer growth rates, and (5) negative.
P. 7-70. Ln. 43.	Reads …only 40% four years; should read …only 40%, 4 years.
P. 7-71. Ln. 21.	Reads …the Subtidal area; should read …the subtidal area.
P. 7-72. Table.	Why is this not with the other tables appended to this chapter?

P. 7-72. Ln. 10. Reads …State Land Commission; should read …State Lands Commission.
P. 7-73. Ln. 6. Reads …0.4 nmh to 1 nmh; should read …0.4 nmh to 1.0 nmh.
P. 7-74. Ln. 13. Reads …southeaster England; should read …southeastern England.
P. 7-75. Ln. 11. Reads …indirect affects; should read …indirect effects.
P. 7-77. Ln. 27. Reads …the Central San Francisco Bay; should read …Central San Francisco Bay.
P. 7-78. Lns. 10, 20, 33. Reads …the Central Bay; should read …Central Bay.
P. 7-78. Lns. 34,35. Reads …does not occur does not occur; should read …does not occur.
P. 7-79. Ln. 26. Reads …portions of water; should read …portions of the water.
P. 7-80. Ln. 3. Reads …juvenile Chinook salmon migration occurs within; should read …juvenile Chinook salmon migrations occur within
P. 7-80. Ln. 7. Reads …entrainment mortality resulting from entrainment; should read …mortality resulting from entrainment.
P. 7-80. Ln. 15. Reads …temporary affect; should read …temporary effect.
P. 7-80. Ln. 18. Reads …predation by predatory; should read …predation by.
P. 7-82. Ln. 5. Reads …the Central Bay; should read …Central Bay.
P. 7-82. Ln. 27. Reads …Northern anchovy serve as; should read …Northern anchovy serves as.
P. 7-83. Ln. 33. Reads …Figure 7-60 sand mining; should read …Figure 7-60, sand mining.
P. 7-83. Ln. 23. Reads …the Central Bay; should read …Central Bay.
P. 7-84. Lns. 9 to 11. Pacific herring also spawn within Humboldt Bay and are exploited by a commercial fishery there.
P. 7-84. Ln. 13. Reads …which coincided with; should read …which coincide with.
P. 7-85. Ln. 4. Reads …associate with; should read …associated with.
P. 7-85. Ln. 24. Reads …the Central Bay and occurs, serve; should read …Central Bay and occurs serve.
P. 7-88. Ln. 30. Reads …has not; should read …have not.
P. 7-88. Ln. 35. Reads …adults(which; should read …adults which.
P. 7-90. Ln. 5. Reads …are difficult; should read …is difficult.
P. 7-94. Ln. 35. English sole in the Bay are primarily small juveniles. Are you sure they are a target of the recreational and commercial fisheries. The same may be true of speckled sanddab, although they are generally small adults.
P. 7-95. Ln. 15. Reads …bass, and; should read …bass and.
P. 7-96. Ln. 37. Reads …(Section 7.3) herring eggs; should read …(Section 7.3), herring eggs.
P. 7-97. Ln. 18. Reads …indirect affects; should read "indirect effects.
P. 7-97. Ln. 26. Reads …potential affects; should read …potential effects.
Figure 7-11. Graph headings read …Suspended; should read …suspended" ….
Figure 7-25. First graph reads mg'; should read …mg/l; both graphs read …Exposure Time; should read …Exposure time to be consistent; and Ln. 1 of the caption reads …Concentration Duration; should read …concentration duration.
Figure 7-26. Heading is messed up with regard to "mg/l" .
Figure 7-29. "Downstream ambient" is boldfaced and italicized and inconsistent with the other labels.
Figure 7-40. Top graph is basically unreadable.
Figure 7-55. Caption reads …and Lincod; should read …and lingcod.
Figure 7-56. Caption reads …Speckled Sanddab; should read …Speckled sanddab.
Figure 7-57. Caption reads …Chinook Salmon; should read …Chinook salmon.
Figure 7-58. Caption reads …Striped Bass; should read …Striped bass.
Figure 7-59. Caption reads …California Halibut; should read …California halibut.
Figure 7-60. Caption reads …Northern Anchovy; …should read Northern anchovy.
Figure 7-61. Caption reads …Pacific Herring; should read …Pacific herring.
Figure 7-62. Caption reads …Bay Shrimp; should read …Bay shrimp.
Table 7-9. Inconsistent capitalization in left hand column.
Tables 7-12, 13, 14. Same as above.
Table 7-15. Inconsistency with respect to other tables in capitalizing the "c" in Chinook.
Table 7-18. Initial capitalization is not consistent in the heading of this table or between this table and others.

Table 7-25. Caption reads …dungeness crab; should read …Dungeness crab.
Table 7-29. Horizontal heading reads …sand mined/month"; should read …Sand mined/month to be consistent with the rest of the heading. Additionally, "Note" reads …San mined; should read …Sand mined.
Table 7-30. Caption reads …Carquineze Strait; should read …"Carquinez Strait.
Table 7-31. Inconsistency in initial capitalization for horizontal heading.
Table 7-34. Same as above.
Table 7-35. Left hand column reads …Carquineze Strait; should read …Carquinez Strait.
Table 7-36. Caption reads …for Crangon spp.; should read …for *Crangon* spp.
Table 7-37. Lack of consistency in initial capitalization in horizontal heading, as well as putting commas in numbers larger than 999. Additionally, "Note" reads …shrimp/key; should read …shrimp/kcy.
Tables 7-38, 39, 40. Same as above.
Table 7-41. Caption is cumbersome using the word "entrainment" three times.
Table 7-44. Five times the final "m" in "Maximum" flips over into the next line. Additionally, the "Note" reads …no event time was; should read no event times were.
Table 7-46. No table border on the right.
Table 7-47. Totals missing on the bottom.
Table 7-59. Table borders?

Chapter 8:

P. 8-2. Ln. 1. Reads …indirect affects of; should read …indirect effects of.
P. 8-2. Ln. 30. Reads …resulted the; should read …resulted in the.
P. 8-3. Ln. 17. Reads …in and a; should read …in a.
P. 8-3. Ln. 23. Reads …Central Bay, sand it; should read …Central Bay, it.
P. 8-3. Ln. 28. Reads …juvenile and fish; should read …juvenile fish.
P. 8-5. Ln. 34. Reads …through the Army Corps; should read …through Army Corps.
P. 8-6. Lns. 36, 41, 43. Figures 7-54 and 7-55 referenced here do not seem to be the ones that correspond correctly with the discussion. Essentially, they address specific fish distributions in Central Bay.
P. 8-9. Ln. 5. Reads …localized affects; should read …localized effects.
P. 8-10. Ln. 25. Reads …staghorn sculpin; should read …Pacific staghorn sculpin.
P. 8-11. Ln. 13. Reads …the he mortality; should read …the mortality.
Table 8-1. "Note" Ln. 1. reads …in Situ; should read …in situ; Ln. 2 reads …SF Bay, was not; should read …SF Bay, were not.

Chapter 9:

P. 9-1. Ln. 27. Reads …mining affects; should read …mining effects.
P. 9-1. Ln. 32. Reads …the one-year; should read …the 1-year.
P. 9-2. Ln. 5. Reads …and depletions; should read …and depletion.
P. 9-3. Ln. 42. Reads …potential affects; should read …potential effects.
P. 9-8. Ln. 31. Reads …with a unique in chemical; should read …with unique chemical.
P. 9-9. Ln. 7. Reads …adverse affects; should read …adverse effects.
P. 9-11. Ln. 6. Reads …(Section 6.2) show; should read …(Section 6.2) show a.
P. 9-11. Ln. 8. Reads …habitat in within; should read …habitat within.
P. 9-15. Ln. 16. Reads …adverse effect on; should read …adverse effects on.
P. 9-16. Ln. 2. Reads …species in inhabiting; should read …species inhabiting.
P. 9-16. Ln. 8. Reads …numbers of in various; should read …numbers of various.
P. 9-16. Ln. 19. Reads …be over in or under; should read …be over or under.
P. 9-17. Lns. 9, 10. Pacific herring do not spawn on sand shoals per se.
P. 9-17. Ln. 13. Reads …the Central Bay; should read …Central Bay.

P. 9-17. Ln. 16. Reads …of nine feet; should read …of 9 feet.
P. 9-18. Ln. 5. Reads …in Section 7.8 it is; should read …in Section 7.8, it is.
P. 9-19. Ln. 10. Reads …includes information; should read …include information.
P. 9-19. Ln. 14. Reads …visual of remote; should read …visual remote.

Chapter 10:

(I was unable to evaluate the entire section due to my lack of familiarity with most the references; here are some general comments:).

- Obviously incomplete, i.e., authors in boldface.
- Page numbers missing from some literature cited.
- Typographical or other minor errors such as misspelling of names, e.g.,:
    - P. 10-1. Ln. 18. Reads …Alpin; should read…Aplin.
    - P. 10-20. Lns. 20, 23. Reads …pacific; should read …Pacific.
    - P. 10-24 Ln. 13. Reads …Rotten; should read …Rutten.

Review: Draft Assessment and Evaluation of the Effects of Sand Mining on Aquatic Habitat and Fishery Populations of Central San Francisco Bay and the Sacramento-San Joaquin Estuary.

By: H. Gary Greene
Moss Landing Marine Laboratories, Center for Habitat Studies/CapRock Geology, Inc.

For: Hanson Environmental, Inc.

Date: March 12, 2004

This report is extensive and appears to incorporate a very thorough literature review. It is well written and presents abundant data in the form of tables and figures. Basically, I found the report to be comprehensive, dealing with most all aspects of impacts that could occur from sand mining in Central San Francisco Bay and the Sacramento-San Joaquin Estuary.

As my background and expertise is in marine geology and the mapping of marine benthic habitats, I have limited my salient comments to those subjects. However, I reviewed the entire document and as the report is based on the available literature, I have made extensive comments about the citations and referencing of papers and reports within the document. Although I read with interest the sections on biology and ecology, my comments on materials presented in these sections are based more on presentation and clarity than on scientific substance. Major comments about the report are as follows:

- Overall illustrations are good, but some are difficult or impossible to read, primarily because originals may not have been in good enough shape to copy properly.
- Some citations of references in text are not included in reference list. Other citations are difficult to track in references because of the liberal use of acronyms. A few listed references were not found cited in text and some references had differing publication dates in reference list and text. The use of "et al." was improperly used in some cases. There needs to be a consistency in the way references are cited, for example some references are cited as Land 1974 while elsewhere it may be cited as Land, 1974 or Newell et al. 1999 or Newell et al., 1999. My copy of the report denotes these discrepancies and I can make it available if you want.
- Units of measurements should be consistent throughout. Both English and metric units are used, but not everywhere are they used together. There should be a standard protocol for using these units such as all units given in metric followed by English units or vise versa.

- In regard to geology, I found the statements about the possibility of tsunamis as a mechanism to replenish sand in Central Bay to be a stretch. First of all the fault motion (strike-slip) along the San Andreas Fault is the wrong motion to produce a large uplift or subsidence on the seafloor that could generate a substantial tsunami. The buried graben associated with the fault probably grew slowly and not catastrophically. In addition, the area of the graben, as well as the shelf area that would be tectonically elevated or downdropped, is not of the size that could generate a large tsunami. The probable source area for a locally generated tsunami is out on the upper continental slope, a fair distance from the Golden Gate and any tsunamis generated there would have to travel across the shallow continental platform before reaching the bay, thus loosing substantial energy in the process. Therefore, I think that tsunamis as a sand replenishment mechanism is insignificant.
- The hypothetical mirror bar is also somewhat of a stretch. I say this not because it could not happen, but that there really is no good data to substantiate this. None of the latest data such as the USGS multibeam bathymetric and backscatter data shows a well-developed bar in the area that is postulated to have such a feature.
- In regard to benthic habitats, I suggest that the impact of sand mining on the morphology of sediment waves be considered, as it is possible that adult migratory fish species such as salmon and sturgeon may conserve energy by resting in the lee of large bedforms when migrating against strong currents. If these bedforms are disturbed and do not rebuild in a reasonable time, their destruction could impair migration of some species. Sediment waves and other bedforms as potential habitats for migratory species have been discussed by Auster, P.J., Lindholm, S., Shaub, G., Funnell, L.S., Kaufman, L.S., and Valentine, P.C., 2003 (Use of sand wave habitats by silver hake, Journal of Fish Biology, 62: 143-152); Haley, N., Boreman, J., and Bain, M., 1996 (Juvenile sturgeon habitat use in the Hudson River (Section VIII: 36 pp. In: Nieder, W.C. and Blair, E.A., eds., Final Reports of the Tibor T. Polgar Fellowship Program, 1995, Hudson River Foundation, NY): Swinn, Brian W., April 2000 (The Hudson Reborn, Access is improved along the river (New York State Conservationist, p. 2-5). In the Swinn (2000) article it is stated "It has been suggested that various fish species that overwinter in the Hudson may lie dormant in these wave fields to avoid being washed downriver by currents." Although this latter reference addresses sandwaves as possible winter hibernation habitats, it is possible that such bedforms can also provide relief or refuge from strong currents for adult migratory fish species on return migrations.
- In discussions of habitats the use of "microhabitats" appears often in the document, however no relationship to scale is given. There needs to be a size relationship given; does a microhabitat refer to features that are centimeters in size or meters in size?
- A pertinent data set for the assessment of sand mining activities in the Bay-Delta area is the San Francisco Bay Watershed Database and Mapping Project produced by NOAA, Office of Response and Restoration, Coastal Protection and Restoration Division. This data set recently (2003) was published in a CD and probably was not available during the time of the literature search. However, it has considerable information that would be helpful in the sand mining assessment including marine benthic habitat maps based on the USGS multibeam bathymetric data and NOS multibeam bathymetry and side-scan sonar data. The habitat maps were constructed at Moss Landing Marine Labs' Center for Habitat Studies using these data sets and can be made available for the sand mining assessment.
- In regard to follow-up studies, it is recommended that digital swath multibeam bathymetry and backscatter data be collected in the areas of present day sand mining activity and adjoining areas for the purpose of monitoring morphological and sedimentological changes on the bay/delta floor. Single beam echosounding would be more time consuming and cover less area than multibeam. Multibeam has the potential to mosaic an area 100% as well as lends itself to digital manipulation in a computer that can produce artificial sun shaded images, slope analyses, and aerial extent of habitat types in a GIS. In addition, time series analyses of the bay and estuary floors can be easily accomplished in a GIS using the multibeam data. Multibeam data can be collected rapidly (at high boat speeds) thereby reducing field data collection costs as well as processing costs.
- A good way to determine sediment transport in the bedform fields is with the use of x,y,z multibeam bathymetry data taken at different times. A sediment additive/subtractive times series image can be produced that can be used to quantify sediment accretion and erosion (see PowerPoint slide attached to this review for an example).

Below are comments made in the text with the page numbers noted and the location of comment associated with paragraph and line, or sentence, number:

Executive Summary

Well written and clear. Does a nice job of outlining problems and activities. Sets the stage nicely.

P. ES-7	Third bullet on page, Dr. H. Gary Green should read Dr. H. Gary Greene.
P. ES-15	First bullet, second line, suggested inserting "in" between "changes" and "land".
P. ES-15	Need to indicate a scale for the term "microhabitat" and 7 lines down suggest deleting "is" between "remain" and "a function".
P. ES-17	Last bullet on page, first sentence, perhaps something should be said about increased food for foraging here.
P. ES-20	Fourth bullet down from top of page, the reference to "extended period of time", suggest quantity be mentioned here, if possible.
P. ES-20	Second set of bullets, suggest that some reference to currents or current studies be made here.

Section 1 – Introduction

A nicely presented and very informative section. I especially liked the review of history

P. 1-2	You may want to look at the San Francisco Bay Watershed Database and Mapping Project CD to seen if these data will be useful. If used, add the reference here.
P. 1-8	Last bullet, first line of bullet, add an "e" to Green.
P. 1-10-1-14	Figures 1 and 2 need explanation of colors. What do the various colors mean, do they have purpose other than showing different leases?

Section 2 – Baseline Conditions

P. 2-19	First bullet on page, second line of bullet, suggest delete "s" from word "Figures" as only one figure is being cited here.
P. 2-25	Fourth full paragraph down from top, 4 lines down, third sentence, citation of Newell et al. (1990) not found in References[1], could this be 1999?

Section 3 – Projected Future Sand Mining Activity

No comments

Section 4 – Physical Characteristics

P. 4-5	Last paragraph on page, 3 lines down, citation of "USACE 1967" is shown in References as "USACOE 1967".

P. 4-6 Top of page, first line, "Table 4-16" is out of place. It is preceded with reference to Table 4-1 on page 4-3 and followed by reference to Table 4-2 on page 4-24.

P. 4-6 Second full paragraph on page, last line, citation of "U.S. Army Corps of Engineer 1967" listed as USACOE (U.S. Army Corps of Engineers). To be consistent list reference in same manner it is cited in the text, as this will help the reader in searching up the reference.

P. 4-7 Last full paragraph on page, second sentence in reference to motion along faults of the graben and the potential to generate a tsunami. The faults are associated with strike-slip motion and although there may be some vertical displacement, it is likely that this displacement occurred slowly and represents wrench-fault tectonics associated with differential horizontal slip. The likelihood of large vertical displacements over a large area in this region is low, thus the potential of generating a tsunamis along this structure is also low. If the San Andreas had a constraining bend to it offshore San Francisco, like near Loma Prieta and in the Transverse Ranges, then the potential of thrust faulting would be possible and the potential of generating a tsunami would be higher then what it is in this locality today.

P. 4-8 Top of page, last sentence, I am not sure what is meant here. What is the difference between the buried faults underlying the bar and the shapes of submarine canyons in Monterey Bay? The San Andreas Fault does not run through Monterey Bay, it extends offshore at the Golden Gate and so this area is the most northern offshore location of the structure. The entire paragraph needs to be better written as the point of the subject is lost. In fact, it may not be germane to the report and may best be left out all together.

P. 4-10 Second paragraph, in reference to the buried channel deeper than 400 feet below sea level being associated with a fault zone, is this an inference that a fault zone may be needed for the channel to be that deep? Even though the channel depth through the Golden Gate is 381 deep, shallower than the 400- foot depth referred to, it is not uncommon to have submarine canyons, or land canyons, increase in depth downstream because a gradient is needed to assure erosion of such features. In other words, a fault zone is not necessary to explain the depth of the channel in this location.

P. 4-11 Second full paragraph, 3 lines down from top, suggest add "(1917)" after "Gilbert".

P. 4-12 Fourth full paragraph down from top, second line down, suggest add parentheses around "1917" after Gilbert so it reads "Gilbert (1917)."

P. 4-12 Fourth full paragraph down, four lines down, suggest change "(Figure 4-12.4 and Figure 4-12.6)" to read "(Figure 4-12a and Figure 4-12b)."

P. 4-13 Top of page, first line, in reference to "Sherman Island, near Pittsburg", suggest show where island and Pittsburg are located on Figure 4-3.

P. 4-13 First paragraph, 5 lines down from top of page, suggest "Smith (1963 and 1966)" be cited as "Smith (1963, 1966)" to be consistent with how other citations have been made; see next paragraph, 3 lines down.

P. 4-13 First paragraph, second line up from bottom, in reference to citation of "U.S. Army Corps of Engineers", this reference is shown in References as USACOE. Suggest changing to be consistent in text and References.

P. 4-13 First full paragraph, 10 lines down from top, citation of "Ogden Beeman and Krone (1992) listed in References as "Ogden Beeman and Krone and Assoc., 1992". Perhaps Ogden Beeman et al. (1992) could work.

P. 4-15 First paragraph at top of page, last sentence, the statement about tsunamis being possible mechanisms for replenishment of sand within Central Bay is a stretch and I would consider this a very remote possibility at best.

P. 4-15	Second full paragraph on page, second line down from top, reference to "the Pleistocene Colma formation", "formation" should be capitalized if it is a formal name, which I think it is. Thus, everywhere in the text I would suggest you refer to this formation as the "Colma Formation".
P. 4-17	First full paragraph, second line down from top of paragraph, reference to the "Franciscan formation", this unit is now referred to as the "Franciscan Complex." Suggest you change to this term.
P. 4-17	Second full paragraph where the discussion of the "Mirror Bar" is made. I have difficulty in seeing evidence for this feature. Although the discussion is somewhat hypothetical, I just think that since there is no real evidence of it existing, it should be described at a lower key. I do like the idea of littoral transported sediment coming into Central Bay from the coast and this appears to be a mechanism that can replenish sand, but the accumulation in a mirror bar does not seem well supported.
P. 4-17	Last paragraph, two lines up from top, the statement that the "possibility of occasional influx of large amounts of sediment carried by tsunamis." just does not ring true to me. There is no evidence of tsunamis deposits in the bay, not any that I am aware of anyway, and the probability of "large amounts of sediment" occasionally being carried by tsunamis into the bay just does not seem like a high probability based on geology and geological history.
P. 4-18	Last two sentences in first paragraph concerning discussion of littoral sediment cells. Suggest that reference be made to Eittreim, S.L., Anima, R.J., and Stevenson, A.J., 2002, Seafloor Geology of the Monterey Bay Area Continental Shelf, Marine Geology, 181, p. 3-34, as these authors also state that the Santa Cruz littoral cell does not extend up to the Golden Gate.
P. 4-18	Last paragraph on page, last sentence in regard to inland transport of gravels. My concern here is that since the ebb tides are nearly as strong as the flood tides, one would expect some transport of the gravels out of the bay as well. However, I am not sure if there is any data to support this thought.
P. 4-20	First paragraph, 6 lines down from top of page, reference to "radar images". Do you mean multibeam images? I would think because of the turbulence of the water here it would be difficult to penetrate to the bay floor using radar.
P. 4-23	Third full paragraph from top, second line down from top, citation of "Smith 1963, 1969", no 1969 date for Smith found in References. Do you mean 1966?
P. 4-24	Last paragraph on page, 5 lines up from bottom of page, reference to "Six of these quadrilaterals are shown for the area . . ." These quadrilaterals are not illustrated on a figure. Suggest you show locations on a map.
P. 4-25	Last paragraph on page, 9 lines up from bottom of page, reference to "microhabitat". Need to define scale for microhabitat.
P. 4.26	First paragraph on page, 16 lines down from top of page, use of word "outcropping" is awkward, suggest use "outcrop" or "exposure". This should carry through the entire document.
P. 4-27	Last Paragraph on page, 7 lines up from bottom of page, use of term "fluffing". I have a question about this term. Does this refer to all overboard discharge, or just fine materials or organic materials?
P. 4-28	Reference to numbered points under heading "***Survey Methods***". This echosounding technique appears out of date. Multibeam bathymetry would do a better job.
P. 4-37	First paragraph, first line at top of page, citation "ADEC et al. (2000)". Why "et al.", not substantiated in References.
P. 4-37	Second paragraph, 9 lines down from top, suggest delete "of" between "… limited to" and water depth…" Phase should read "…limited to water depth…"

P. 4-38	Second paragraph, in reference to topic of using core samples to estimate sand distribution. Densities of core sample locations need to be taken in consideration here. Without good coverage estimates may be suspect.
P. 4-43	Last paragraph, first sentence not complete. Sentence reads "During these maximum flow events, the current was probably completely downstream…" Suggest re-write to read "During these maximum flow events, the current direction probably flowed completely downstream…"
P. 4-44	First paragraph, in reference to units used for depth and water flow, suggest add metric equivalents so that consistent use of units throughout entire document is obtained and both English and metric units are represented.
P. 4-44	Third paragraph, 4 lines down, citation of "(Conomos and Peterson, 1976) not found in References.
P. 4-44	Last paragraph, 6 lines up from bottom of page, suggest add the word "have" between "…impoundments that" and "been constructed…"
P. 4-45	Second paragraph a bit repetitive. Last sentence in reference to tsunamis as representing possible inland-directed sediment transport is weak and modeling of such a phenomenon needs to done before seriously considering this as a potential sand replenishment mechanism.
P. 4-45	Third paragraph, last sentence in reference to "… significant portion of the transport …" Significant should be quantified in some fashion.
P. 4-45	Last paragraph, 5 lines up from bottom of page, suggest replace word "of" between "… tide events" and "the ocean coast." with "along."
P. 4-46	First paragraph under heading **4.5.1**, 4 lines down, reference to "…much higher levels." Much higher levels than what?
P. 4-46	Second paragraph under heading **4.5.1**, 2 lines up from bottom, suggest delete "d" from "decreased".
P. 4-55	Second paragraph down from top of page, first line, suggest add a "d" to "an" between "…data presented" and "analyzed…"
P. 4-59	Last paragraph, second to last sentence, where it states "…note there is a peak in suspended sediment concentrations during mid-1994 (a drought period) that does not correspond to any clear change in the Delta Outflow Index." Why? Can you give an explanation for this?
Fig. 4-8	This figure needs a reference. After whom?
Fig. 4-9	Citation in figure caption of USGS map GP-1006 not found in References.
Fig. 4-10	Seismic reflection lines difficult to read. Also, reference to "Ultra-high resolution seismic reflection profiles …" needs to be associated with a frequency. What is the fundamental frequency of the system? And, is it possible to state what the rate of sand extraction is where you say the sand is being mined from the actively deforming fault zone?
Fig. 4-13	Source of figure needs to be cited. No morphology shown for the hypothetical "Mirror Bar" making the feature suspect. Also, I might have missed it, but I could not find reference to this figure in the text. It probably should be cited on page 4.12, in third full paragraph.
Fig. 4-17a	Need to cite source of this data. USGS? Also, data is not backscatter but bathymetry (x,y,z data).

Fig. 4-18	Suggest you state where these data stations are located and if possible show on a map (figure).
Fig. 4-21a,b	Should the citation here be "Ogden Beeman and Krone, 1992?
Fig. 4-22b	Figure not clear, hard to read.
Figs 4-41-46	Need explanation of colors. Are these presented just to show different lease blocks or do they have another purpose?
Fig. 4-50	Cannot distinguish the difference between gravel and sand deposits. Both are shown in yellow.
Figs. 4-51-53	Suggest adding notation to colored area in the captions of these figures. For example, "Area of Central Bay with water depths between 30 and 90 feet shown in yellow."
Fig. 4-59a	Need to indicate what colors mean here.
Fig. 4-92	Sample stations hard to read in this figure.
Fig. 4-103	Sampling areas difficult to see. Suggest using different color or make the station symbols larger.
Fig. 4-106	Citation RMP, 2001 not found in References.
Fig. 4-107	Citation RMP, 2001 not found in References.
Table 4-6	Even though negative values were referred to in caption, I could not find negative values in table.

Section 5 – Aquatic Habitats and Fish Community

P. 5-1	Third paragraph down from top, 5 lines down from top, sentence reads "Zooplankton Pacific herring." Suggest it to read something like "Zooplankton is eaten by Pacific herring."
P. 5-3	Third full paragraph down from top, 12 lines down from top, citation "(Wyllie-Echeverria and Rutten, 1989)". "Rutten" is shown as "Rotten" in References.
P. 5-4	First paragraph, second line, same as above for P. 5-3, "Rutten" cited where it is shown as "Rotten" in References. Also, last sentence in this paragraph needs a reference cited for this statement.
P. 5-4	Second paragraph, references to Merkel in this paragraph is listed as Merkel and Associates in References. Should be the same in both places.
P. 5-4	Third paragraph, 5 lines down, suggest replace "of" between "…position" and "the base…" with "at".
P. 5-12	Footnote, is "The U.S. Fish and Wildlife Service (1995)" a citation as I did see it in References?
P. 5-16	Third order heading near bottom of page: "***Results of CDFG Sampling Program: Occurrence of Species Status Species***", suggest replace first "Species" with "Special".
P. 5-18	Last paragraph, 4 lines down, suggest replace "for" between "…that float" and "drift passively" with "or".
P. 5-20	Last bullet on this page, suggest change "rock outcropping" to read "rock outcrop" or "rock exposure".
P. 5-23	Last bullet on this page, same comment as above.

P. 5-24	Second paragraph, third line up from bottom, suggest change “rock outcroppings” to “rock outcrops” or “rock exposures”.
P. 5-25	Last full paragraph on page, last sentence of paragraph, Table 5-21 was not included in my binder.
P. 5-27	First paragraph, 5 lines down from top, citation “(Spatt, 1992)” not found in Reference. Do you mean “Spatt, 1988”?
Fig. 5-2	Figure a bit fuzzy, difficult to read.
Fig. 5-5a	Two different locations shown for Station 213. Should this be changed? Indicate red dots represent sand mining locations.
Fig. 5-7	Suggest caption to read “Pacific herring spawing ground within Central Bay shown in purple”.

Section 6 – Physical Changes in Environment …

P. 6-2	First paragraph, last line, suggest change “year” between “…cubic” and “per year…” to “yards”.
P. 6-6	Second full paragraph on page, second line up from bottom, I find that the reference to the possibility of sediment deposited in Central San Francisco Bay by tsunamis to be weak. It is certainly possible that a tsunami may have swept sand into the bay, but I know of no good evidence to support this.
P. 6-10	Last paragraph, 4 lines down, should citation of “Ogden Beeman and Krone, 1992” read “Ogden Beeman and Assoc., and Krone and Assoc. or Ogden Beeman et al.”? Listed as “Ogden Beeman and Assoc. and Krone and Assoc.” in References.
P. 6-11	First paragraph, second line, citation of “Trivedi’s (1995)” reference listed as 1996 in References.
P. 6-13	First full paragraph, 5 lines down, sentence “Since sand mining activity occurs within the deeper navigational shipping channels.” is not complete. Suggest do not start following sentence with “Therefore” and continue sentence in question as “…shipping channels, therefore, sand mining would not be …”
P. 6-14	In heading **6.4.2** the word “Environmental” should probably be “Environment” so the heading reads “**Projected Changes in Physical Environment Resulting from Projected Future Mining Activity, by Area**”

Section 7 – Assessment of Potential Direct and Indirect Impacts …

P. 7-1	Last paragraph, last line, citation “Groot (1979)” not found in References.
P. 7-3	First paragraph, 6 lines down, citation “Servizi and Martens, 1992 listed as 1991 in References.
P. 7-6	Third full paragraph on page, last sentence of paragraph, something missing from last part of sentence. Perhaps replace the comma with an “and” between “…increased turbidity” and “could occur…” so that the last line in the paragraph reads “…increased turbidity and could occur within an area where aquatic vegetation is present.”
P. 7-8	First bullet under heading **7.4.2**, last line, the citation “Bruton, 1985” is listed in References as “Burton”.
P. 7-9	Fist line and 4 lines down from top of page the citation “Bruton, 1985” is listed in References as “Burton”.

P. 7-9	Second line down from top of page, citation of “Gray and ward, 1982”, “w” in ward needs to be capitalized.
P. 7-9	Third bullet on page, 4 lines down from top of bullet, the citation of “Bisson and Bibly (1982)” is listed in References as “Bisson and Billy”.
P. 7-9	First paragraph beneath bullets, 4 lines up from bottom, suggest insert the word “contribute” between “…that could” and “to additive…”
P. 7-10	First full paragraph on page, 3 lines down from top, citation of “Messiech et al., 1981” listed as “Messieh, with no “c” and a date of “1991” in References.
P. 7-13	Last paragraph, second line up from bottom of page, citation of “Morgan et al., 1973” not found in References.
P. 7-15	First and second full paragraphs, citation of “O’Connor et al. (1977) listed as “1976” in References.
P. 7-18	Second full paragraph beneath bullets, 3 and 4 lines down, citation of “Bruton, 1985” listed as “Burton” in References.
P. 7-18	Third paragraph beneath bullets, second line down, suggest replace “where” with “were” between “These experiments” and “carried out …”
P. 7-19	First paragraph, 10 lines down from top of page, citation of “Servizi and Martens 1992” listed as “1991” in References.
P. 7-19	Frist paragraph, 4 lines up from bottom of paragraph, suggest delete “an” between “…exposed to” and “suspended sediment…”
P. 7-20	First paragraph, second line down from top of page, citation of “SJRG 2001” not listed the same in References, acronym is spelled out in References. Also, citation “(Bailey and Monroe 2001)” not found in References.
P. 7-23	Fourth paragraph down from top, 5 lines down from top of paragraph, suggest lower case letter for “b” of “Bay” and add an “s” to the word so that it will then read “For species occurring in Central and Suisun bays…”
P. 7-24	First paragraph, 9 lines down from top of page, citation “Peddicord et al., 1975” listed as “1976” in References.
P. 7-25	Second paragraph, 5 lines down from top, in reference to “50-100 mg/”, suggest add an “l” after “mg/” so it reads “50-100 m/l”.
P. 7-25	Third paragraph on page, third line down from top, in reference to the use of side scan sonar for determining avoidance response by pelagic species needs to be better explained. How was the side scan sonar used to determine this? Were repeated passes made so that movement of fish balls could be documented? Was a time series effort made?
P. 7-27	Last paragraph on page, 7 lines down from top, suggest delete “to be no” located between “…sand mining” and “significantly higher …” and replace with “were not” so that it reads “….contamination of the sediments harvested by sand mining were not significantly higher…”
P. 7-28	Start of paragraphs 1,2 and 3, citation of “MEC and Cheney (1990)” not found in References. Do you mean “MEC Analytical Systems, Inc.”?

P. 7-29	Fourth paragraph down from top, 7 lines down, suggest delete "the basis" from sentence where located between "… technical basis" and "for the RWQCB…" Also, in this line and the second line above this line citation of "MEC (1993)" is inconsistent with the citation of "MEC Analytical Systems (1993)" found in References. The citation of this reference should be consistent throughout the document.
P. 7-30	Second full paragraph, 6 lines down from top, suggest add a comma after "In general" at start of sentence.
P. 7-33	Fourth paragraph down from top, second line down from top, start of sentence should "Data were collected…" as data is plural. Same comment holds for next sentence so that the start of that sentence should read "These data were averaged…".
P. 7-33	Last paragraph on page, 3 lines down from top, citation of "(EPA 2000)" not found in References.
P. 7-34	Fourth paragraph down from top, 9 lines down from top, suggest replace "was" after "data" with "were".
P. 7-36	Second paragraph, 5 and 6 lines down from top, citation of "(MEC and Chaney 1990)" not found in References.
P. 7-38	First full paragraph, below bullet, 9 lines down, suggest citations of "Armstrong, Stevens and Hoeman (1982, 1987)" be cited as "Armstrong et al." as other 3 authored citations in the document are treated this way.
P. 7-38	First full paragraph, below bullet, 12 lines down, citation "Wainwright (1990, 1992)", 1992 not found in References.
P. 7-40	Third paragraph down, 5 lines down, suggest delete parenthesis in citation (McGraw et al. (1988)", too many parentheses.
P. 7-41	Last paragraph on page, second line down, "R" in "Reported" after citation should be lower case.
P. 7-41	Suggest change citations of "Armstrong, Stevens and Hoeman (1982)" in third and fourth paragraphs on this page to read "Armstrong et al."
P. 7-41	Second paragraph, 6 lines down from top, at start of sentence add an "a" to "By…" so that the sentence reads "Bay shrimp were …"
P. 7-43	Last paragraph, second line up from bottom of page, suggest placing the date in parentheses here before "Table 7-22;" so it reads "Larson and Moehl (1990; Table 7-22)".
P. 7-45	First paragraph under heading "**Methololgy**" second line up from bottom, should citation "McGraw (1988)" read McGraw et al. (1988)."
P. 7-46	Second paragraph under heading **<u>Results</u>**, second line down suggest replacing the word "was" after "data" and end of line with the word "were." Also, at the end of this paragraph citation "(CDFG, 1999)" could not be found in References.
P. 7-47	First paragraph after heading ***Shrimp***, 5 lines down from top, end of sentence here ends with "…the four." Four what? Need to add something here, how about "…the four locations."?
P. 7-48	Second full paragraph on page, 13 lines down, suggest delete "in" at end of line here so that it reads, "… during the month entrained …"
P. 7-48	Second full paragraph on page, 14 lines down, at end of line where it reads "…the number of fish and train during …", suggest deleting "and train" and replace with "entrained".

P. 7-49	Second full paragraph on page, 4 lines up from bottom, citation "PG&E 1981, 1982)" is listed in References for 1981 as "1981a" and "1981b", which one is the citation for? If for both, cite as "(PG&E, 1981a, b)".
P. 7-50	Second paragraph after heading **7.8.1**, 2 lines down, need to spell out somewhere, in text or References, what "DOER" means. Also, throughout this paragraph the citation of "Popper 2003" is used but it is not listed in References.
P. 7-51	First paragraph, 6 lines down from top of page, suggest replace "this" with "these" before word "data" at end of line.
P. 7-51	Second paragraph, second line down from top, in reference to sound propagation velocity in water as being 1,500 m/s, it must be stated that this is an average speed in normal ocean sea water. The velocity of sound is dependent upon temperature and salinity and would vary considerably within the San Francisco Bay/Delta depending on salinity. It would be especially variable if considerable fresh water were flowing through the system; I doubt that it is right at 1500 m/s. Also, the attenuation of a sound, as alluded to in the last sentence of this paragraph, is dependent upon frequency as much as upon energy.
P. 7-51	The citation of "Popper 2003" throughout fourth paragraph could not be found in References.
P. 7-52	Second paragraph after heading **7.8.2**, second line down, citation of "(San Luis Delta Mendota Water Authority and Hanson, 1994)" appears to be listed as "1996" in References. Also, third line in this paragraph refers to "Georgiana Slough", which should be shown on a figure (map) somewhere.
P. 7-52	Third paragraph after heading **7.8.2**, first line, suggest replace word "sand" with "sound" so that sentence reads "Richardson et al. (1990) studied "sound" pressure levels …"
P. 7-53	Last paragraph, 5 lines up from bottom of page, citation of "Green (1987)" listed as "Greene" with an "e" in References.
P. 7-54	First paragraph, 5 lines down from top of page, suggest add "by" after "… the medium measured" and before "Richardson et al. …"
P. 7-54	Second paragraph, 3 lines up from bottom suggest add a comma after "10 m deep" and before "frequencies around 30 Hz …" Also, in second line up from bottom of this paragraph, the citation of "(Rogers and Cox, 1988)" is listed in the References as "Roger" without an "s".
P. 7-55	Last paragraph, 3 lines down from top, citation of "(Scholik and Yan 2000a) is not listed in References. In fact 3 references for Scholik and Yan, 2000 are listed in the References; need to distinguish by assigning "a, b, and c" to listed references for this citation. There is a "b" for this reference listed, however.
P. 7-56	First paragraph, first line, need reference for "The National Manufacturers Association". Also, in the paragraph the citation of "Scholik and Yan, 2002a" was not found in References.
P. 7-56	Paragraphs 2, 4 and 5, in regard to citation "(San Luis and Delta Mendota Water Authority and Hanson 1994), do you mean "1996" as listed in References?
P. 7-57	Second paragraph, 5 lines down, citation "Popper and Fay (1973)" listed as "1993" in References. Also, at end of line suggest delete "to" so that sentence reads "…to establish that fish vary in their hearing …"
P. 7-58	Third full paragraph, last sentence not complete. Need to say what happened when the sound signal was on.
P. 7-59	First paragraph, citation of "Scholik and Yan, 2002a" not found in References.

P. 7-60	Second paragraph, 5 lines down, sentence "While on was a hearing specialist, the goldfish." is not complete and is confusing. Needs to be corrected.
P. 7-60	Last paragraph on page, 3 lines up from bottom of page, citation of "(San Luis and Delta Mendota Water Authority and Hanson 1994)" is listed as "1996" in References.
P. 7-61	Paragraphs 2, 3 and 6, same comment about citation as above for P. 7-60.
P. 7-62	Paragraphs 3 and 4, same comment about citation as above for P. 7-60.
P. 7-63	Paragraphs 2 and 4,same comment about citation as above for P. 7-60.
P. 7-63	Third paragraph, 8 lines down, suggest adding a parenthesis after "…hatching" so it reads "…fry (56-110 days from hatching)."
P. 7-64	Last paragraph, citation of "(San Luis and Delta Mendota Water Aurthority and Hanson, 1994)" listed as "1996" in References.
P. 7-65	Third paragraph, suggest deleting the "A" after the "Jones, A 1986" and the "G" after "Jones, G. 1996" as these two references are of different dates and there should be no confusion in what reference is being cited. Also, in this same paragraph, 5 lines up from bottom, citation of "COE" not found in References. This appears to be listed as "USCOE". Also, citation "FWS 1970" appears to be listed as "USFWS 1970" in References.
P. 7-65	Third paragraph, 3 lines up from bottom, citation of "McCauley et al., 1976" is listed as "1977" in References.
P. 7-67	Last paragraph, 7 and 8 lines up from bottom, suggest removing dashes after dates of citations and replace with commas, so these references are cited in a consistent manner, similar to other citations in the document. Also, 3 lines up from bottom of page in this paragraph, suggest add "(1985)" after citation of "Nichols and Thompson".
P. 7-77	First paragraph, 13 lines down from top of page, sentence starting on this line not complete. At end of 14th line down from top, suggest that "data" is inserted after "…habitat information," so that this part of the sentence reads "…habitat information, data were compiled for …"
P. 7-77	Second paragraph, 3 lines down, need to spell out "WESCO".
P. 7-78	First paragraph, 15 lines down from top of page, the sentence "Shiner perch distribution and habitat use within Central Bay, particularly in suspended sediments associated with dredge material disposal and relatively high water velocities within the area." is not complete.
P. 7-78	In paragraphs 1 and 2 suggest that "outcroppings" be changed to "outcrops" or "exposures".
P. 7-80	Third paragraph, suggest add something about bedforms being potential habitats for migratory species of fishes and discuss what the impacts of bedform disturbance may have on these fishes. See bulleted discussion of this at beginning of this review.
P. 7-81	Paragraphs 1 and 2 where "outcroppings" are discussed, suggest changing to "outcrops" or "exposures."
P. 7-83	End of first full paragraph, in regard to discussion of the time an overflow plume would dissipate, suggest quantify the statement "…within a relatively short period of time.". This is relative to what?

P. 7-84	Second full paragraph, same comment as for P. 7-81 above.
P. 7-87	First full paragraph on page, citation “San Francisco Bay-Delta Aquatic Habitat Institute (1992)” not found in References.
P. 7-89	First paragraph after heading **Summary**, suggest replace “outcroppings” with “outcrops” or “exposures”.
P. 7-93	First paragraph after heading ***Suisun Bay***, suggest locating “Honker Bay” on a figure (map) for reference purposes.
P. 7-94	First full paragraph on page, 5 lines down, suggest deleting word “of” between “…abundance for several” and “fish species, …”
P. 7-95	Second paragraph. Was only one charter boat captain interviewed? It seems that a couple of different interviews would be necessary to obtain a statistically valid conclusion. However, I realize that these interviews are probably beyond the scope of this report as it is primarily a literature review.
Fig. 7-10	Citation of “O’Conner et al. 1977” in caption could not be found in References.
Pig. 7-27	Citation of “MEC and Cheney, 1990” could not be found in References.
Fig. 7-26	Difficult to read. Location information needs to be larger and of a different color.
Fig. 7-35	Citation “CDFG, 1999” not found in References.
Fig. 7-37	Difficult to read, poor photo reproduction.
Fig. 7-38	Difficult to read, poor photo reproduction.
Fig. 7-42	Is the “acoustic signal” referred to in the caption human or artificially generated sound?
Fig. 7-43	Citation “San Luis and Delta Mendota Water Authority and Hanson, 1995” listed as “1996” in References.
Fig. 7-43	Same comment as for Fig. 7-43 above. Also, this figure nearly unreadable.
Fig. 7-47	Give explanation of colors.
Fig. 7-48	Give explanation of colors.
Fig. 7-51	This figure shows areas of change, but it would be nice if the areas could be shown as either negative or positive changes in bathymetry, in other words areas of sediment erosion and accretion.
Fig. 7-52	Same comment as for Fig. 7-51 above.
Figs. 7-54-62	Suggest explain color areas, for example “Shiner Perch Central Bay habitat usage, shown in purple. Yellow dots are mining events.”
Table 7-17	Citation “EPA 2000” not found in References.
Table 7-19	Under “Source” column in this table suggest refer to “Armstrong, Stevens, and Hoeman 1982” as “Armstrong et al., 1982”. Also, Wainwright et al. 1990” listed as just “Wainwright” in References.
Table 7-23	Citation “PIE 2002” is spelled out in References. Suggest do the same here.

Table 7-24 Citation “McCabe et al. 1986” not found in References.

Table 7-51 Source “Wang 1986 & NOAA”, NOAA not found in References. Need a proper citation for this source.

Table 7-56-62 Citation of “San Luis and Delta Mendota Water Authority and Hanson 1994” not found in References.

Section 8 – Cumulative Effects

P. 8-1 First paragraph, 7 lines down, suggest insert letter “t” after “However,” and before “here”, so that sentence reads “However, there is no …”

P. 8-2 Second full paragraph, citation in this paragraph of “Ogden Beeman and Krone (1992)” should be consistent with how it is listed in References. Also, in line 7 of this paragraph suggest adding “(1992)” after the citation.

P. 8-3 First full paragraph, 9 lines down, suggest deleting “and” between “…in” and “a” so it reads “… to result in a long-term depletion …” Same paragraph, 2 lines up from bottom, suggest deleting “sand” between “Bay” and “it” so sentence reads “In the Central Bay it appears that sand …”

P. 8-4 First full paragraph, 3 lines down from top, need to insert “1992” after “Ogden Beeman and Krone” and cite it as listed in References.

P. 8-4 First full paragraph, 19 lines down, the term “microhabitat scale” needs a defined scale notation. Does this relate to cm or m size features?

P. 8-5 First full paragraph, suggest changing “outcroppings” to “outcrops” or “exposures”.

P. 8-8 Second full paragraph, first line, citation “MEC and Cheney (1990)” not found in References.

P. 8-9 Second full paragraph, suggest add something in this paragraph that addresses bedform disturbances and any potential consequence to fish habitat. It may be that these bedforms are reformed shortly after mining or that mining events are of the periodicity that bedforms can be re-established by the time upstream migration of fishes occurs. At any rate, I think there should be a statement about bedform disturbances in this part of the document.

P. 8-11 First paragraph, 3 lines up from bottom, suggest delete “he” between “the” and “mortality” so that the sentence reads “… contribute to the mortality rates …”

P. 8-15 First bullet, suggest that a statement about bedform disturbances be included in this paragraph and a reference to how this disturbance may affect migratory species.

Section 9 – Recommendation for Additional Investigations

P. 9-2 First paragraph, 5 lines down, where a discussion of recommended bathymetric surveys occurs. My recommendation would be to use the most up-to-date and hydrographic compatible method to undertake the recommended monitoring surveys. High-resolution bathymetric mapping systems such as the Reson 8101 or 8111, ~200 kHz, bathymetric mapping systems would do a very nice job in imaging the areas where sand harvesting is occurring. In addition, these systems obtain 100% coverage and the data can be readily be processed in GIS. These would be ideal systems for doing time series analyses.

P. 9-4 Second full paragraph, first couple of lines in relation to the review of bathymetric data collected for monitoring sand mining activities. I assume that tidal corrections are part of the processing of the data and these corrections would be reviewed.

P. 9-5 I would suggest that the NOAA benthic habitat maps constructed from the USGS and NOAA multibeam bathymetry and side scan sonar data be mentioned here. Even though these data were not available at the time this document construction was initiated, the data should probably be addressed in some fashion here.

P. 9-6 Second paragraph, it should be noted here that if a multibeam bathymentric system was used, 100% coverage could be obtained easily. The same statement would also hold for what is discussed in the last sentence of paragraph 3.

P. 9-7 Much of the discussion here about bathymetric surveys is somewhat old fashion. The new multibeam technologies have improved on the cost effectiveness of collecting bathymetric data and are very good at repeatability if good differential GPS navigation is available. In addition, the bathymetric images collected with multibeam systems are easily manipulated in GIS, which can result in very accurate assessments of bathymetric changes.

P. 9-8 First paragraph. In relation to protocols for bathymetric data collection to monitor changes in seafloor conditions associated with sand mining, I would suggest setting up these protocols based on multibeam technology. Pre- and post-mining surveys should be done as well as seasonal surveys. Surveys both in and out of sand mining areas should be done as suggested by the authors of this report. However, if multibeam bathymetric systems are used for the surveys, much of the sand mining and adjoining areas can be surveyed in a day or so.

P. 9-8 Second paragraph, 9 lines down, suggest that citations "ACOE, WES 1976" should be cited in same fashion as listed in References (i.e., USACOE, USWES).

P. 9-8 Second paragraph, last sentence, in reference to sediment traps and the determination of dynamic sediment movement fashions, I suggest that multibeam bathymetry be considered for this type of analyses. I have included a PowerPoint slide with this review to show how the migration of sand waves can be illustrated using multibeam bathymetry in GIS.

P. 9-9 First paragraph, last sentence. The use of multibeam bathymetry and backscatter would be very helpful in analyzing the potential for sand replenishment. Multibeam backscatter data can be used in the same fashion as side scan sonar data, but it would be accurately georeferenced to the bathymetry providing an excellent method to determine the dynamics of the bay/delta floor.

P. 9-10 First paragraph, 4 lines down, citation "ACOE WES 1976" not listed in References as cited here.

P. 9-10 First paragraph, 6 lines down from top of page, suggest add "and multibeam bathymetric surveys" between "…sediment traps" and "to access bedload movement …"

P. 9-11 First paragraph, 8 lines down, suggest delete "in" after "habitat" and before "within".

P. 9-14 First paragraph, first two lines, evaluation of the distribution and abundance of fish need to be explained better. What is the procedure of doing this and how will abundances be calculated from the acoustic images?

P. 9-18 Third sentence down. The recommended evaluations listed in this paragraph can be accomplished very well with the use of multibeam bathymentric data sets. I suggest that multibeam bathymetric data be considered here.

P. 9-18 Last paragraph. Suggest that multibeam bathymetric technologies be considered here to evaluate the physical changes in benthic habitats associated with sand mining.

P. 9-29 Second paragraph, last sentence, reference to the better reporting in track logs of when dredging actually starts and ends would not be necessary with multibeam data sets as accurate imaging of the disturbance from dredging can be shown.

Section 10 – Literature Cited

P. 10-2 Arthur, J.F. and M.D. Ball. 1979. Not found in text.
Battalio, R. and D. Trivedi. 1996. Cited as 1994 on p. 6-11.
Bisson, P.A. and R.E. Bilby. 1982. Cited as "Bibley on p. 7-9.

P. 10-3 Burton, M.N. 1985. Cited as "Bruton" on Pgs. 7-8, 7-9 and 7-18.

P. 10-4 Chapman, C.J. and A.D. Hawkins. 1973. Cited as 1969 on p. 7-63.

p. 10-7 Graymer, R.A., Sarna-Wojcicki, J. Walker, R. McLaughlin and R. Fleck. 2002. Not found cited in text. Also, first comma of reference out of place.

P. 10-9 **Hawkins, A.D. 1969.** Not found cited in text.

P. 10-12 McCauley, J.E., R.A. Parr, and D.R. Hancock. 1977. Cited as 1976 on p. 7-65.

P. 10-13 Merkel and Associates. 2000. Not found cited in text.
Merkel and Associates. 2000a. Cited on p. 5-4 as Merkel only.

P. 10-14 Newell, R.C., D.R. Hitchcock and L.J. Seiderer. 1999. Cited as 1990 on p. 2-25.

P. 10-15 O'Connor, J.M., D.A. Neumann and J.A. Sherk. 1976. Is this a duplicate of the following reference? This reference cited as 1997 on p. 7-15.

Ogden Beeman and Ass. and R.B. Krone Ass. 1992. "Ass." not included in citations in text.

P. 10-16 Peddicord, R.K., V.A. McFarland, D.P. Belfiori and T.E. Byrd. (no date). Not found cited in text.

Peddicord, R.K. and V. McFarland. 1976. Cited on p. 7-24 as 1975.

P. 10-17 Popper, A.N. and R.R. Fay. 1993. Cited on p. 7-57 as "1973".
Regional Water Quality Control Board, San Francisco Bay Region (SFBRWQCB). 2000. I may have missed this in text, did not find.
Roger, P.H. and M. Cox. 1988. Cited with an "s" as "Rogers" on p. 7-54.

P. 10-18 San Luis and Delta Mendota Water Authority and C.H. Hanson. 1996. Cited as "1994" on pgs. 4-52, 7-56, 7-60, 7-61, 7-62, 7-63, 7-64, Tables 7-56, 7-57, 7-58, 7-59, 7-60, 7-61, and Figures 7-43 and 7-44.

P. 10-19 Scholik, A.R. and H.Y. Yan. 2002 and 2002b are all same authors with same date, 3 in total. These references need to be designated with a, b, and c. As it stands it is very confusing and the reader is not able to distinguish which reference(s) is being referred to in the text. Servizi, J.A. and D. Martens. 1991. Cited as "1991" on pgs. 7-3 and 7-19.

P. 10-20 San Joaquin River Group (SJRG). 2001. I may have missed this, but could not find cited in text.

Smith, B. 1966. Cited as 1969 on p. 4-23.

P. 10-22 USACOE (U.S. Army Corps of Engineers). 1967. Cited by USACE on p. 4-5. Also Army Corps of Engineers on pgs. 4-6 and 4-13.

USACOE, USCOE, and COE are all used in various citations in text. These should be cited in a consistent manner. As it stands it is confusing to the reader. USEPA. 2000. Not found in text. **U.S. NAVY. 1950s??. San Francisco Bay Sediment Report** not found cited in text.

P. 10-23 **Wainwright 1990**. Cited as Wainwright et al. on Table 7-19. Wainwright, T.C., D. Armstrong, P.A. Dinnel and J.M. Orensanz. 1992. Cited as "Wainwright (1992)" on p. 7-38. **WESCO** 1958? See pg. 7-77.

p. 10-24 Wyllie-Echeverria, S. and P. Rotten. 1989. Cited as "Wyllie-Echeverria and Rutten" on p. 5-3 and 5-4.

Conclusion of Review

I found this report to be a comprehensive and well articulated assessment of the effects of sand mining on aquatic habitats and fishery populations within the Central San Francisco Bay and Sacramento-San Joaquin Estuary. It appears that a fairly thorough literature review was made and that the recommendations based on this review are reasonable. The major scientific concerns I have, although not serious, are in regard to the proposed tsunami and hypothetical mirror bar sand replenishment mechanism. These do not seem to be significant replenishment processes, although it is probably worthwhile mentioning the possibilities of such phenomenon. In addition, I think that the disturbance of the mega-bedform features such as sand waves from sand mining activity should be addressed in the report in respect to the potential disruption of ephemeral migratory species' habitat. Although not proven, or even well investigated, new insight and observations of migratory species such as salmon suggest that the lee sides of dynamic bedforms may provide refuge from strong downstream or outflowing currents during times of upstream migration. It is possible that due to strong seabed currents and plentiful sand supply that these bedforms rebuild rapidly after a mining event. However, the potential impact to these bedforms still needs to be addressed.

I recommend that the incorporation of multibeam bathymetric and backscatter data sets be considered for future evaluation of sand harvesting impacts on the bay/delta floors and benthos. These data sets are easily manipulated in a computer and would facilitate running time series analyses of the bay/delta floor dynamic processes. In addition, the use of this modern technology would provide a cost effective and rapid methodology to obtain data for monitoring mining and natural processes.

As the report was primarily based on literature review, I spent considerable time checking references. My major concern in this regard is that not all references cited in the text are listed properly in the Literature Cited section. More attention needs to be assigned to the way references are cited in the text and listed in the Literature Cited section. Citations should be consistent and the use of acronyms avoided if at all possible. If acronyms are used, they should be consistently used throughout the document. Some references listed in the Literature Cited section were not found cited in the text, while few references were listed in the Literature Cited section but not found cited in the text.

Overall the document was clearly written. Only a few incomplete or confusing sentences were found, a remarkable feat for such a large document obviously requiring multiple inputs from many people. I think the effort represents hard work and thoughtful writing.

I hope that my comments are taken constructively, as that was the intent of my review. It was a pleasure to review the report and I would be willing to discuss my comments at any time.

Respectfully submitted by:

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132 Cottage Lane
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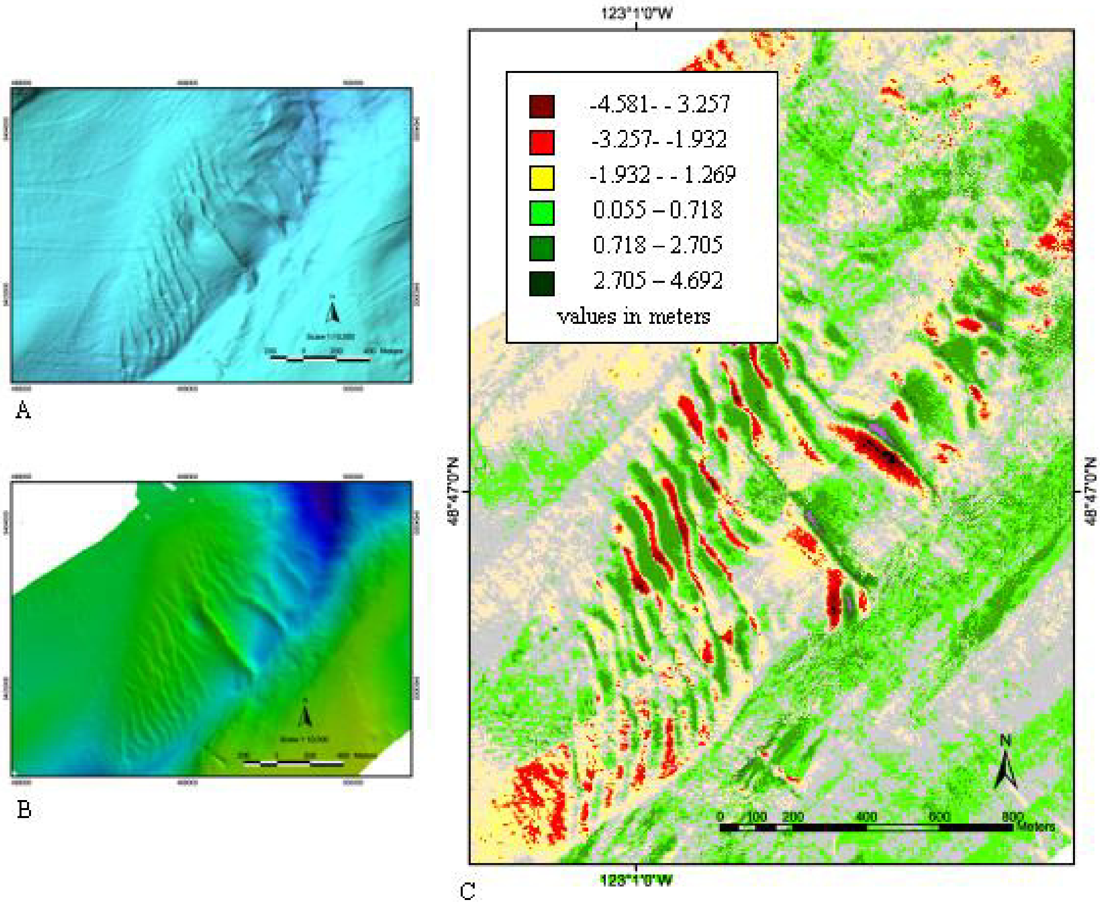

Figure5. Dynamic sand waves in the Boundary Pass region, Canada. Image A displays Simrad EM 1002 95 kHz multibeam bathymetry data collected in 2001 and Image B displays multibeam bathymetry data collected in 2003 with the same sonar system in the same area. Note migration of sand waves. Both images, created in the GIS program, ArcMap®, are shown with at a scale of 1:50,000. Using the GIS program, ArcMap®, two 5 m grids were subtracted using *Raster Calculator,* as seen in Image C, which calculates differences at each pixel location. These grids are comprised of data collected in 2001 and 2003 in the Boundary Pass region of Canada. The red and green colors represent migration of the sand waves where red = crests and green = troughs.

Review of "Assessment and evaluation of the effects of sand mining on aquatic habitat and fishery populations of Central San Francisco Bay and the Sacramento-San Joaquin Estuary" by Hanson Environmental

By David Schoellhamer, U.S. Geological Survey, March 8, 2004

In general, the report is well written and it contains a lot of information that has not been available or centrally located. Given the information that is available, it is wise to start with a literature review and compilation of available data as is done in this report. The report will be a valuable resource on sand mining for the Bay community.

As with any report of this size and breadth, there are some things that should be improved. I briefly summarize the most important improvements in this paragraph and describe them more completely in my remaining detailed comments. There is an important typo in transferring the results of table 4-4 to the text that affects some of the interpretation in the report. The report would be improved by providing more quantitative comparisons of sand mining rates with what is known of sediment supply and bathymetric change. 'Change' can be determined relative to conditions without sand mining or in time. This distinction is not clear in the report. Lack of bathymetric change in time does not mean that sand mining is not causing a change relative to if sand mining did not occur. The term 'tidal prism' is not properly used in the report.

Executive summary

The executive summary is well written and comprehensive. The statements of the report purpose at the beginning seem repetitive. Comments on the subsequent chapters apply to the executive summary also. The executive summary should be modified to reflect changes to the rest of the report.

Page 2: The scope is said to be limited to review and analysis, but new and useful information on sand mining events is presented in this report. This should be added to the scope.

Page 6: It would probably be useful to a few people if the electronic databases developed for this report were released.

Page 8: 'dissolved and colloidal clay particles': There is no such thing as a dissolved particle, so please reword.

Page 9: The last 2 paragraphs have virtually the same first sentence, please revise.

Page 11: The importance of salt flocculation has always been debated (Meade 1972) and generally flocculation is found to occur in freshwater (papers by Droppo) and this estuary appears to be no different. Suspended sediments are flocs, even in freshwater (Ganju and Schoellhamer 2003). This correction needs to be made elsewhere in this report.

Page 14: The potential effect on the sediment budget is not listed here but it is discussed on the next page, so please add it to the list.

Page 15: Reference is made to a change of plus or minus 10 feet but the time frame for this change should be given or it should be expressed as a rate.

Page 16, last sentence: 'microhabitat scale changes' mean changes in flow velocity resulting from mining. This definition is not clear and when I first read this I thought it meant that mining did not change the local benthos, which it does as stated on the next page. I suggest replacing 'microhabitat scale changes' with a more clear term.

Page 18: State why there was a shift in locations of mining.

Chapter 1, Introduction, project description and purpose of assessment

Page 2: The scope is said to be limited to review and analysis, but new and useful information on sand mining events is presented in this report. This should be added to the scope.

Page 7: It would probably be useful to a few people if the electronic databases developed for this report were released.

Chapter 2, Sand mining activity (environmental baseline conditions)

Section 2.1: If possible, please provide a figure showing the quantity of sand mined as a function of time from 1930 to the present. If those records are not available, can the capacity of the sand mining fleet (cy) be plotted as a function of time to show the growth of the industry?

Section 2.2.1: When searching for suitable material, what is the fraction of fine sediment in the material that is commonly mined? On page 2-20 this is given as being less than 10%, please state this here. The size cutoff for fine sediment should be defined (see page 2-21 comment).

Some sand mining events were close to USGS continuous SSC monitoring stations. The data could be analyzed to observe any effect or lack thereof of sand mining from March 2002- Feb 2003 when the detailed sand mining data are available.

Section 2.3: This analysis of sand mining events helps the reader understand sand mining operations and is a valuable part of the report.

Table 2-9: Values in this table differ slightly from sand mining quantities in the quarterly Corps of Engineers dredging reports. The Corps reports have much larger quantities for Suisun Bay. Perhaps they report Grossi values. Values for 2001 and 2002 are not correctly summed.

Throughout this section and report, the quantity of mined sand is reported as cubic yards. Please provide a value for the dry bulk density of mined sand in the Bay (mass per volume) so that the reader can covert cubic yards to mass if desired. Is the density of mined sand less than sand at the bottom of the Bay? The report mentions loose and compacted sand, so the density of Bay bottom sand must vary. Is a cubic yard of mined sand equal to a cubic yard of sand on the bottom of the Bay? Note: this is given on page 4-13, it should be given earlier. Note: fluffing is mentioned on page 4-27 whereby mined sand is less dense than in situ sand, this should be mentioned earlier.

Page 2-19: Please correct 'dissolved clay particles' here and elsewhere in the report.

Page 2-19, bottom: I did some limited unpublished sampling in a plume from a maintenance dredge in Tampa Bay in the 1980s and found that SSC within the plume did not appear to correlate with the visible plume, as stated here.

Table 2-15: Smaller silts and clays will flocculate and the flocs will have a settling velocity greater than given in the table. The given settling velocity underestimates the settling of silts and clays.

Page 2-21: Fine sediment is defined as being smaller than 200 microns, but the common definition for engineers and geologists is 63 microns. If you mean 200 microns, I suggest that you replace 'fine sediment' with '200 microns'. Later in the report, the more common definition of 63 microns is used, so I suspect the 200 is a typo.

Page 2-29: Change 'farmfield' to 'far field'.

Chapter 3, Projected future sand mining activity

No comments

Chapter 4, Physical and water quality characteristics of the Bay-Delta estuary

Page 4-2, first sentence: Change 'sentiment' to 'sediment'.

Figures 4-1 and 4-2: These conceptual models should be described where they are introduced.

Page 4-6, first line: Reference table 4-1b, not 4-16.

Page 4-6: Spot measurements of SSC by the USGS are mentioned, but not the continuous measurements of SSC by the USGS. See http://ca.water.usgs.gov/abstract/sfbay/sfbaycontbib.html for a list of references and available links. Interpretive reports and articles are also listed.

Page 4-12: Filling of the bay is mentioned, but diking of baylands also reduced tidal prism, perhaps more than filling. Diking should be mentioned too.

Page 4-13: The importance of salt flocculation has always been debated (Meade 1972) and generally flocculation is found to occur in freshwater (papers by Droppo) and this estuary appears to be no different. Suspended sediments are flocs, even in freshwater (Ganju and Schoellhamer 2003). This correction needs to be made elsewhere in this report.

Page 4-16: I believe the reference to figure 4-15a should be west of the Golden Gate (Bridge), not east.

Page 4-18: Sand removed by mining is taken from the subtidal Bay, so the tidal prism of the Bay will not increase. The water volume of the Bay will increase. The report should be corrected.

Figure 4-18: More labeling of where these transects were taken and in which directions would be helpful and allow determination of the direction of transport from the asymmetry of the bedforms. As I recall this area, transport would be seaward.

Figure 4-21a: The bathymetry data processed by Bruce Jaffe and his colleagues is of greater resolution than Krone's data. Comparison of sand mining locations with the higher resolution data would be more likely to show a correlation if one exists.

Page 4-26, top: A conclusion of this analysis is that it is difficult to identify a cause and effect relationship between sand mining and bathymetry change, with which I concur.

Page 4-26, last paragraph: The tide range in South Bay is greater than at the Golden Gate, so filling or diking the Bay there would have a greater effect on a per area of basis. This paragraph should be corrected.

Page 4-27, section 4.26: This section is on the effect of the water projects, which is anthropogenic, so it seems that it should be part of section 4.25.

Page 4.27: section numbering in incorrect.

Section 4.2.7 Changes in bathymetry resulting from sand mining on a regional and local scale:

Survey Methods: State the vertical and horizontal accuracy of the method.

Survey Results: This variability is huge and it provides more information on sand dynamics in Central Bay. The variability in Central Bay is also about what Krone saw in surveys 35 years apart in Central Bay, so the seasonal to annual variability may be greater than the decadal variability. Given the recent sudden accumulation of 10-15 feet of sand at the USGS and NOAA Presidio gage house after decades of operation, these shifts seem plausible. The biannual results show that frequent surveys are needed to understand sand dynamics in the Bay. These surveys provide a wealth of data to better understand sand dynamics and the industry and regulatory agencies should be commended for collecting these data. I do have some concerns with the results in table 4-4. If an initial or final survey were in error, then the net change will be biased. Parcels 709 North, 709 South, 7779 East, and 7779 North have an initial or final survey that may bias their results (an initial or final entry that is much larger than the other entries). If two consecutive entries in table 4-4 oscillate wildly positive/negative, then the middle of the three surveys used to determine the two entries may be in error (too high or too low, causing the two entry oscillation). Parcels 709 South, 5871, and 7779 West have two consecutive entries that oscillate wildly. The suspect surveys may be fine but they should be checked for accuracy. A better way to determine the rate of change would be to calculate the median of the rate of change for every pair of surveys for a parcel (4 surveys would yield 6 estimates of rate of accretion). The median would diminish the effect of outliers.

Page 4-29: There is a huge typo at the end of the third paragraph: according to table 4-4 the net depletion from the central Bay survey sites is 26 million cy, not 2.6 million cy stated in the text. My calculations based on the numbers in the table confirm 26 million cy. Sand mining removes about 1.4 million cy per year from Central Bay (table 2-9) and thus accounts for only about 5 million cy or 19% of the observed depletion (January 1999 to July 2002). Because sand is coming in from the Golden Gate, where did all this sand go? The natural spatial variation must be huge. The answer to this question will greatly improve our understanding of sand dynamics in Central Bay. (The regional surveys recommended in chapter 9 should answer this question). Please check the numbers in this table.

Table 4-5: Comments on table 4-4 above apply here. The initial survey for 5733 is suspect. 7781 West has a large oscillating pair. I assume that 'Western Delta' refers to Carquinez Strait and Suisun Bay. Is the Grossi lease not included in the survey data?

Page 4-31, section 4.2.8: It seems that these results should be presented here.

Page 4-32: The one foot variation found by Krone is small compared to the biannual surveys presented in this report.

Page 4-33: I disagree with the conclusion that Central Bay does not appear to have significant net erosion. 26 mcy disappeared from much of the bottom of Central Bay over a 3.5 year period. This paragraph should be revised.

A missing fact is that Porterfield (1980) estimated that the 1909-1966 bedload into the Delta was 67,000 metric tons/year. The value into Suisun Bay would be expected to be less due to deposition and reduced flows.

4.3 Distribution and abundance of sand

Figures 4-54 and 55: Give the source of the peak velocity information.

Pages 4-36 and 37: Over a 3.5 year period, 26 mcy were lost from Central Bay, which is most of the sand according to Goldman (40 mcy total) and ADEC (60 mcy). It does not seem realistic that most of the sand would disappear in 3.5 years. The larger USGS estimate seems more reasonable.

4.4 Hydrodynamics

Page 4-39: Add gravitational circulation to this introductory discussion.

Page 4-42: The conceptual model of gravitational circulation is dated and should be revised, see Schoellhamer, D.H., and Burau, J.R., 1998, Summary of findings about circulation and the estuarine turbidity maximum in Suisun Bay, California, U.S. Geological Survey Fact Sheet FS-047-98, 6 p. URL: http://sfbay.wr.usgs.gov/access/suisunbay/dschoell/

Page 4-42: , last paragraph: Some sand transport occurs during typical tidal flows. Figure 4-18 shows bedforms whose shape indicates that they are moving. The web page http://ca.water.usgs.gov/program/sfbay/calfedsed/ shows an example from the Sacramento River. I agree that most transport happens during high river flow.

4.5 Water and sediment quality characteristics

Page 4-51: I believe that the USGS sampling program began in 1969, but data may be available on the internet only back to 1977.

Continuous salinity and temperature data: These have been collected by the USGS for many years and should be mentioned in this section. Data are available at http://sfbay.wr.usgs.gov/access/Fixed_sta/ . See Buchanan, P.A., 2002, Water level, specific conductance, and water temperature data, San Francisco Bay, California, for Water Year 2000: Interagency Ecological Program Newsletter, v. 15, no. 1, p. 22-26. URL: http://www.iep.ca.gov/report/newsletter/2002winter/IEPNewsletterWinter2002.pdf and other similar reports at http://ca.water.usgs.gov/abstract/sfbay/sfbaycontbib.html .

4.6 Turbidity and suspended sediments

Continuous SSC data have been collected by the USGS for many years and should be mentioned in this section. Data are available at http://sfbay.wr.usgs.gov/access/Fixed_sta/ . See Buchanan, P.A., and Ganju, N.K., 2002, Summary of suspended-sediment concentration data, San Francisco Bay, California, water year 2000: U.S. Geological Survey Open File Report 02-146. URL http://water.usgs.gov/pubs/of/ofr02146/ and other similar reports at http://ca.water.usgs.gov/abstract/sfbay/sfbaycontbib.html .

The analysis in the second paragraph of section 4.6.1 is compromised because the data presented are not continuous. The data in these figures should be plotted as points, no lines. See references at the website above for discussion of continuous SSC data.

Page 4-56: I have had similar problems identify dredging plumes from the water surface.

Page 4-57, first full paragraph: I do not understand the first sentence. For several years we have calibrated turbidity and SSC in the Bay and the relation is good. This turbidity discussion The second half of this paragraph is wrong. See references above and web site.

Page 4-58 and figure 4-116: TSS in the figure is less than 70, not 87 or 104 given in text.

Page 4-58, last paragraph: How were areas of upwelling determined? Areas of high SSC? Were these determined visually? I though you could not do this from previous comments. If high SSC was used to sample, of course SSC was higher. SSC will be patchy.

Section 4.6.3: Comparing monthly grab samples with daily data is not appropriate, especially the anomalies. See previous references.

Summary: Modify this section for my previous comments on this chapter.

Chapter 5, Aquatic habitats and fish community

The material in this chapter is not my field of expertise, so I have no comments.

Chapter 6, Physical changes in environment relating to sand mining – San Francisco Bay and Delta sediment characteristics

Page 6-1, last paragraph: Provide references for the first sentence. I doubt that sand supply to the estuary from the river has increased because dams trap sand and reduce the peak flows that transport sand. These points should be better developed or deleted.

Page 6-2, rivers, last sentence: Suspended-sediment supply has been decreasing in the Sacramento River over the past 50 years, so I think this is incorrect and should be deleted. See Wright, S.A. and Schoellhamer, D.H., 2003, Trends in the sediment yield of the Sacramento River, 1957-2001: Proceedings of the 2003 CALFED Science Conference, Sacramento, California, January 14-16, 2003, p. 177. http://ca.water.usgs.gov/abstract/sfbay/abstractsedimentyield2003.html

Page 6-5, filling, last sentence: Lower tidal currents would tend to increase deposition of sediment supplied to the estuary, please correct.

Page 6-5, oysters and subsidence: Deepening the Bay does not increase the tidal prism. Increasing the volume of water that fills the bay from low tide to high tide increases the tidal prism. This is a common mistake in this report that needs to be corrected.

Page 6-5, dredging: Obsolete dredging data from 1977 are presented here. The data are obsolete because sediment supply has decreased and disposal practices have changed. Corps records show that from 1995-2001 4.1 mcy/yr were dredged and 47% was disposed upland or in the ocean. Please update.

Page 6-6, sand mining: Sand mining will not increase tidal prism.

Page 6-6, Suisun Bay: There is still some bed load transport at low flows. Reservoirs do reduce peak flows and therefore sand transport down the rivers.

Page 6-7, last sentence: Natural filling of the estuary's margins is offset by sea level rise. On a geologic scale, sea level has risen faster than estuarine filling. It would thus seem that reduction of tidal currents at the Gate can not be caused by natural processes.

Page 6-8, last paragraph: I doubt that sand supply to the estuary from the river has increased because dams trap sand and reduce the peak flows that transport sand.

Page 6-9, second paragraph: see previous flocculation comments. Even accepting the salt flocculation conceptual model, salinity is high enough in central Bay where the material is flocculated.

Section 6.2: A clear quantitative comparison of sand mining extraction and estimated rates of sand supply to Suisun Bay and Central Bay, with uncertainty, would improve this section.

Page 6-9, last paragraph: The phrase 'no notable bathymetric changes in Suisun Bay' should be changed to 'no notable deepening in Suisun Bay'. If sand mining removes as much sand as comes in, then sand mining does change bathymetry, making it deeper than it would be otherwise. The comparison mentioned above would be helpful.

Page 6-10, first paragraph of 6.3: If sand mining is maintaining tidal velocities and the location of mixing zones, then it is causing a change compared to what would be happening in the absence of sand mining. Change is being defined here as change in time, not to a condition of no sand mining. This distinction should be made clear and change relative to both frames of reference should be discussed.

Page 6-11: The 2.6 mcy should be 26 mcy, see chapter 4 comment. This paragraph will have to be rewritten.

Page 6-12: The phrase 'no observed bathymetric change' should be changed to 'no observed deepening '.

Page 6-12, 6.3.4: Based on the information in tables 1-1 and 2-9, I calculate that the average mining from Suisun Bay is about 0.1 feet per year in the lease areas. Over time, this depletion is a significant number. Capiella et al. show erosion from 1942-1990 in the Suisun Bay sand mining areas of perhaps 10 feet. If the sand mining rate has been constant, sand mining would have removed about 6 of the 10 feet. They also calculate that the net erosion in all of Suisun Bay from 1942-1990 was 1.3 mcy/year. At a rate of 150,000 cy/yr (table 2-9), sand mining would account for 11% of the observed erosion. This comparison and other quantitative comparisons would improve this report. Sand mining rates have apparently increased, so these results probably overestimate the effect of sand mining. More historical information on sand mining would improve this comparison.

Section 6.4: Previous chapter 6 comments apply here.

Section 6.4.1, second paragraph: My comparison of Capiella et al. and the Suisun Bay sand mining areas is that the area south of Chipps and Van Sickle Island has eroded 1942-1990 by perhaps 10 feet. Bruce Jaffe should be able to better comment on this. Thus, there has been deepening in some channels where sand mining has occurred. The first sentence of this paragraph should be modified or better justified. The table 4-4 typo appears here again. The last sentence should be deleted (tidal prism).

Section 6.4.2: A more quantitative analysis is needed to prove that sand mining rates in Suisun Bay are sustainable.

Chapter 7, Assessment of potential direct and indirect impacts of sand mining on aquatic species and their habitat

Most of the material in this chapter is outside my field of expertise, so I have few comments.

Page 7-8: Worst case: because the plume will settle exponentially, this seems like a very conservative (bad) worst case.

Page 7-25: Please provide a reference to the Alcatraz side scan sonar study of fish dispersing in a plume.

Section 7.10, habitat change: In chapter 6, this section was referred to as 7.9, not 7.10. NOAA charts from 1975 and 2001 are compared. I believe that charts contain information from multiple surveys that are conducted years apart (1942 and 1990 in Suisun Bay according to Capiella et al.). Thus, charts should not be used to estimate bathymetric change. Bruce Jaffe regularly works with NOAA data and can describe this issue in more detail.

Chapter 8, Cumulative Effects

Page 8-3, middle of page: The statement that sand supply exceeds harvest in Suisun Bay should be better justified. The biannual surveys showed sand accretion in the Suisun Bay mining areas, but the 1942-1990 surveys show depletion. The bed load into the Delta (Porterfield 1980) needs to be evaluated too. A more rigorous quantification of supply and mining would be helpful.

Page 8-3, bottom and page 8-6: The problems with using the 1975 and 2001 bathymetric charts for bathymetric analysis have been described previously.

Page 8-5, top: The statement on the effect of dredging on tidal prism needs to be modified.

Page 8-12, item 2, first sentence: I do not understand this sentence, please rewrite. It seems to say that bathymetric surveys tell us that fish and clams are unhappy if depth changes by more than 10 feet. It is also earlier in the report, but I thought it would get clearer, but it has not.

Page 8-12, item 3: there is contradictory evidence on whether the sand mining areas in Suisun Bay are accreting or depleting.

Page 8-12, last item: Habitat restoration is also planned for San Pablo Bay. This item only addresses the effect, and lack thereof, of sand mining on Delta restoration. The 1975-2001 bathymetric chart issue is here too.

Page 8-14, second bullet: This seems to contradict bullets on pages 8-12 and 8-13.

Chapter 9, Recommendations for additional investigations

Bathymetric surveys: My biggest concern from the biannual surveys is that there are 26 mcy of sediment that moved out of the mining areas that is unaccounted for. Has it shifted to the Presidio shoreline? Our conceptual model of sand in Central Bay is that it must stay in the Bay because sand is coming in through the Gate. A regional survey covering all of Central Bay would answer this question and provide much more information on sediment dynamics in Central Bay. I am glad to see that this is a recommendation. The existing data shows a lot of seasonal variation, so I would suggest doing the surveying in

September when inflow is low and has been for months to the estuary may have recovered from the previous winter's pulse of water and sediment. In addition, winds are light to improve quality and the spring/neap tide variation is small so any effect from changes in tidal energy over several days will be minimized. The site specific surveys have provided a lot of information but the regional survey would seem more valuable and a regional survey would still coarsely cover the mining areas. This would also probably eliminate the need for reference sites discussed later in this chapter.

Sediment dynamics and sediment budget: The USGS is revising the 1955-1990 sediment budget for the entire Bay and is developing a budget for 1995-2002. Sand dynamics in Central Bay and sediment flux at the Gate are the most uncertain items. Both budgets will include sand mining. The USGS has successfully used bedform mapping to estimate sand transport in the Delta and perhaps the methodology could be applied to Central Bay (http://ca.water.usgs.gov/program/sfbay/calfedsed/). They key question relative to sand mining is the rate of replenishment, and this technique may be very helpful.

Reference sites: Given the spatial variation that must be taking place, I worry that a few reference sites will not provide useful information. A regional survey is the best way to account for the spatial variation.

Reviewer: Dr. Bruce Jaffe, USGS
March 17, 2004

Review comments on "Assessment and Evaluation of the Effects of Sand Mining on Aquatic Habitat and Fishery Populations of Central San Francisco Bay and the Sacramento – San Joaquin Estuary" by Charles H. Hanson, John Coil, Barry Keller, Jennifer Johnson, Justin Taplin, Jud Monroe, and Hanson Environmental, Inc.

Thank you for the opportunity to review this report. This report contains very useful information on sand mining. I have focused my comments on areas where I have expertise-- the geologic, bathymetric, and sediment transport information contained in the report.

Summary of Important Issues

1. This report does not adequately explain the sediment dynamics for sand in Central Bay. It is difficult, if not impossible; to assess the impact of sand mining in Central Bay without knowing how the sand is transported to Central Bay and where sand mined in Central Bay would be transported to if it were not mined.
2. The conceptual model that sand is transported only as bedload is not supported by theory, by size analysis of suspended sediment samples collected in the bay, by in situ measurements of suspended sediment grain size in the bay (Sternberg et al., 1986), and by sand layers in sediment cores on the shoals of San Pablo Bay (Allison et al, 2003). The significance of suspended load transport of sand is that sand can be transported large distances rapidly in suspension compared to bedload transport of sand. Suspended load sand transport increases the regions of the bay where sand can be transported to and makes the sand system more interconnected. For example, large volumes of sand from North Bay (and the Sacramento and San Joaquin Rivers) can be transported to Central Bay during a single flood as suspended load. It is possible that a single large flood deliveries more sand to the bay than many years of non-flood periods.
3. This report focuses on local rather than regional effects of sand mining. The effects of sand mining are evaluated locally (e.g., extent of local scour) but are not adequately evaluated regionally. For example, the effect of sand mining at Middle Ground Shoal, Carquinez Strait, and near Chips Island on habitat in Suisun, Grizzly, Honker, and San Pablo Bays are not adequately addressed. To evaluate regional issues, the long-term trends in habitat change need to be addressed to determine if recent changes are anomalous. Sand Mining volumes need to be evaluated relative to the sand input from rivers and the ocean. To glean recent changes from causes other than sand mining (e.g., changes in sediment supply), a 3D coupled hydrodynamic/sediment transport/geomorphic model should be run with cases that isolate non-mining effects on habitat change.
4. Navigational charts, rather than hydrographic sheets (H-sheets) are used to address long-term bathymetric and habitat change. Navigational charts are an inferior data source compared to H-sheets— they have 100 times less data than H-sheets and depth soundings on charts are from different years (sometimes taken several decades before

the chart is printed). Typically, the only soundings added or changed on a chart are ones that affect navigation. A comparison of charts is not as accurate as a comparison of H-sheets (or survey data) and can be misleading. For example, rates of net sedimentation (Cappiella et al., 1999; Jaffe et al., 1998, Foxgrover et al., unpublished) are very different from Ogden Beeman and Ass. and R.B. Krone and Ass. (1992). We determined net sedimentation in San Pablo Bay for the area defined by Ogden Beeman and Ass. and R.B. Krone and Ass. (1992) using H-sheets. We calculated that San Pablo Bay had an average of –0.7 million cubic meters/yr of erosion for the period 1955-1990 (actual years of surveys were 1951 and 1983). Ogden Beeman and Ass. and R.B. Krone and Ass. (1992), using charts, calculated 0.15 million cubic meters of accretion for this same period.

5. Data used to in the report does not include key studies and databases. As a result of missing this key information, the conceptual models and approaches to assessing the effects of sand mining are limited. Missing studies are too numerous to list. These include Schoellhamer's large data set and studies on suspended sediment concentrations and transport and Porterfield's 1980 report on sediment transport from streams to the estuary. There is substantially more data on grain size than was included in the report including: Conomos (1963), Locke (1971), Rubin and McCulloch (1979), Hampton et al. (2003). Grain size data is important for assessing sand transport in the bay and for determining the effects of sand mining on habitat.
6. The effects of sand mining are not quantified adequately. For example, the report uses phrases such as, "not expected to result in substantial changes", "did not show a significant pattern of change", "appears to be negligible", without defining substantial, significant, and negligible.
7. Cumulative effects should include the combination of sand mining and the increase in tidal prism from restoration projects. Cumulative effects should also include sand mining combined with the increase in upland and ocean disposal of dredge spoils. The USACE is planning to increase ocean and upland disposal of dredge spoils (pers. Comm. Tom Kendall, USACE).
8. The Recommendations for Additional Studies section does not consider the value of studies that exploit information that can be learned from bay-floor sediment properties. These include: (1) quantifying temporal and spatial variation of bay floor sediment grain size, and (2) provenance of sand. The grain size information will aid in improving the understanding of sediment dynamics and sand budget. Collection of grain size data at the same time that bathymetric surveys are conducted will help understand the seasonal (and longer term) fluctuations in net sedimentation (i.e., is sand or mud deposition and erosion causing the volume fluctuations observed in the surveys). Grain size data in habitats of concern will quantify the contribution of sand to maintaining the habitat. Provenance studies will help determine the source of the sand (ocean vs. river; specific rivers) and also improve the understanding of sediment transport pathways.
9. The Recommendations for Additional Studies section does not consider changing the coverage of bathymetric surveys. Complete coverage less frequently, or perhaps a nested scheme, would document how non-mining areas changed for comparison with mining areas. This baseline is very useful for determining non-mining effects. Such data could also be used to evaluate where the 26 million cy of sediment that is eroded from Central Bay is deposited.
10. The Recommendations for Additional Studies section does not consider the value of 3D coupled hydrodynamic/sediment transport/geomorphic for resolving key issues such as where the sand comes from and where it would be deposited were it not mined. Such models can also determine causes other than sand mining that result in habitat change.

General Comments on Terminology and Figures

1. In places, the terminology used in the sediment and bathymetry parts of the report are not standard. I have pointed out some of the non-standard terminology in the "Specific Issues and Comments" below.
2. Add scale bars to all maps.

Specific Issue and Comments (key: 4-12/3/3 = page 4-12, paragraph 3, line 3)

ES1-21//: Most of my comments are on the individual sections—not the Executive Summary. All comments for sections 4 and 6-9 are intended to be incorporated into the Executive Summary. I have several comments on the Executive Summary.

ES-10/2/5: Cappiella et al. (1999) clearly show that the navigational channels of Suisun Bay and Middle Ground Shoal are erosional from 1942-90. I disagree with the statement that, " there appears to be a

general pattern of accretions [sic] within the navigational channels of Suisun Bay, Middle Ground Shoal".
ES-10/3/18: I am not sure what is meant by "no constant evidence" in the sentence, "Results of these analyses provided no constant evidence to suggest that current sand mining has contributed to sediment depletion on a regional scale that would be sufficient to adversely impact quality or availability of subtidal habitat within the estuary." Sediment depletion on the regional scale is not adequately addressed in the report (see later comments for specifics).
2/all: This is an extremely informative section. I have not commented on choices for evaluating sediment concentrations in the plume because Dr. Schoellhamer will probably comment on this.
4-1/3/1: It is not necessary to include mud in your definition of fine sediment when silt and clay is included (mud is defined as both the silt and clay particles).
4-1/4/3: What is meant by, "to hydraulic factors of the interaction of the inflow from rivers and tidal action"?
4-3/4/1: Any conclusions based on two samples are extremely misleading because of spatial and temporal variability of grain size (see Hampton et al., 2003). This is especially the case when the samples are "mechanically altered."
4-3/4/8: Mined sand is not representative of sediment on the bay floor. Take out the qualifiers that suggest mined sand is representative of sediment on the bay floor.
Figures 4-5 and 4-6: The colors of the sand in these figures are very off. The bad color is misleading. Corrected colors should be used in these figures.
4-4/1/2: A comparison of mined sand to possible sand sources is misleading because of mined sand is not the same as the sand on the bay floor.
4-5/1/2: A USGS scientist who studies alteration of minerals in the marine environment did not think it likely that that the "desert varnish" formed by alteration in the marine environment.
4-5/5/2: The studies of Schoellhamer (numerous) and Sternberg et al. (1986), and many others are not considered in this report. They should be.
4-5/5/4: The correct published studies by my group are not included in this report. The web pages are included, but the date of reference is incorrect (2001). The correct reports to consult (and to use for graphics—there are nice clean Adobe Illustrator figures) are two USGS Open-File Reports, Cappiella et al. (1999) and Jaffe et al. (1998).
4-6/1/1: Typo: should be Table 4-1b, not 4-16.
4-6/2/3: More than "spot" measurements of suspended sediment concentration can and have been made by Schoellhamer at many places in the estuary. Schoellhamer's measurements are high frequency and continuous (except for instrument problems). He has made the measurements for many years.
4-6/2/7: I agree that it is difficult to use "spot" measurements to estimate mass transport of sediment. However, Schoellhamer has made such estimates (and error estimates on the quantities) using concentration and flow measurements.
4-6/2/15: The "rates of compaction within the estuarine system, which are often unknown" can be estimated using existing sediment core density data or by theory.
4-6/4/5: Battalio and Trivedi (1996) is not a peer-reviewed article. It is an article in conference proceedings, which does not require peer review. Data and results from this article should be critically evaluated before using in this report.
4-12/4/all: The effect of the San Francisco bar on sand transport in the bay, as well as the sand net transport rate at the Golden Gate, can be addressed using a numerical coupled 3D hydrodynamic/morphologic/sediment transport model. There are several such models that exist (e.g., Delft3D) that could be used to get quantitative answers to these questions.

4-13/1/5: Results from Porterfield (1980), a key study for sediment input
to the bay from rivers, should be included in this report.
4-13/2/4: From 1957-66, sand was 43% (by mass) of the total suspended load for the Sacramento River at Sacramento (Porterfield, 1980; pg 41). Unless conditions have changed drastically, and sand is not transported from Sacramento to the bay, the statement, "Most of this is very fine material that is carried as suspended load in the moving water, with a very minor percentage being fine sand that is carried as bedload along the bottom" is not correct. Not only is sand an important part of the suspended load; sand moving in bedload is significant. Porterfield (1980) estimated that, with the addition of sand moving as bedload, sand was 52% of the total sediment discharge on the Sacramento River at Sacramento from 1957-66.
4-13/2/last sentence: Sand does get transported into San Pablo Bay during floods. Sediment cores collected on the shoals of San Pablo Bay, away from local streams, show sand layers in x-radiographs (Allison et al., 2003).
4-13/3/2: Typo: change 62 microns to 63 microns.
4-13/3/last sentence: I disagree with the statement, "However, the suspended load transport and deposition process probably has little influence on the sand deposits, which result from bedload flow along the bottom." The last 2 comments, and the 2nd comment in General Issues contain my reasoning.
4-14/1/12: Tributaries down-estuary can contribute sand upestuary. Gravitational circulation (examples of studies showing gravitational circulation in the San Francisco estuary are: Burau et al., 1993; Gartner and Burau, 1999) will move sand upestuary.
4-14/3/8: What is the basis for the statement, "bedload sand transport may not presently occur downstream of San Pablo Bay"?
4-15/1/4: I have studied tsunami sediment transport for 10 years. Although, undoubtedly, a tsunami would transport some sand from the ocean to the bay, I doubt the volume transported would be comparable to other processes for sand transport to the bay. Although it is possible that sand transport during a tsunami is a significant source of sediment for Tillamook Bay, because San Francisco Bay is deeper and river and tidal sediment transport is stronger than Tillamook Bay, a tsunami is probably not a significant source of sediment for San Francisco Bay.
4-18/3/10: Inward movement of sediment from the bar does not imply that mining is not important. If the bar is both a sink and a source of sediment to the bay, the net would change if the amount of sand going to the bar decreases for any reason. Because the sediment dynamics of the Central Bay are not given in this report, it is not possible to assess if mining effects the balance of sediment in and out of the Golden Gate (and the amount of sediment in the bar).
4-19/1/last sentence: There are areas outside of Central Bay other than maintained ship channels that are deep. Most of the main channel in San Pablo is not dredged or significantly affected by dredging and averages 12 m in depth, with a maximum depth of 24 m.
4-20/1/6: Change "radar images" to "multibeam images".
4-20/1/7: The statement, "This progression requires higher flow velocity with greater water depth and with finer grain size" in not correct. The progression from lower flat beds to upper flat beds requires higher flow velocity for **coarser** grain sizes. Higher flow velocity is required because coarser grain sizes have greater critical shear stress for initiation of motion and lower transport rates for the same flow velocity.
4-20/1/last sentence: Chin has published a side-scan sonar image of Suisun Bay as part of Hampton et al. (2003). This image shows bedforms.
4-20/2/11: Net sand transport direction can be determined from bedforms.
Rubin and McCulloch (1979) did this for Central Bay.

4-21/3/all: Missing Chin's side-scan data from Hampton et al. (2003).
4-22/3/all: H-sheets, not navigational charts, should be used as the basis for any bathymetric change. Charts are an inferior data source compared to H-sheets— they have 100 times less data than H-sheets and depth soundings on charts are from different years (sometimes taken several decades before the chart is printed). Typically, the only soundings added or changed on a chart are ones that affect navigation. A comparison of charts is not as accurate as a comparison of H-sheets (or survey data) and can be misleading. (See the rest of General Issue 4 for the effect of using charts vs. H-sheets).
4-22/4/1: H-sheets are readily available from NOS/NOAA.
4-22/4/2: The report by Cappiella et al. (2002), which took an equivalent of one person working full time for approximately 2 years, uses GIS surface modeling software to create continuous bay floor surfaces for all H-sheets from 1867 to 1990.
4-25/3/8 and 4-26/1/1: Areas of sand mining are compared to sedimentation from 1955 to1990 (bulk of the bathymetric data is not from these exact dates). This comparison is only valid for indicating cause and effect if sand mining was done for the entire period from 1955 to 1990. If sand mining was not done for the entire period, the sedimentation is mainly a non-mining signal. One wouldn't expect a correlation between mining and a mainly non-mining signal. Was sand mining done for the entire period at the locations of the comparisons?
4-28/3/3: Was the tide gauge from Crissy Field used for all areas of the bay? If so, this introduces an error because of lag between tides at Crissy Field and other areas of the bay. This error would be difficult to detect because it would change depending on phase of the tide.
4-29 and 4-30/ Survey Results: As is suggested in the section on Recommendations for Additional Studies, the error in the short-term hydrographic survey comparisons needs to be quantified. This can be done to some extent using existing data. Areas where independent surveys were run at approximately the same time that have overlapping regions can be compared to estimate error. For example, area 5871 overlaps with 7779 West and 709 South. Soundings from these surveys should be the same, unless there is error or they were not surveyed close enough in time that actual change was significant. Error analysis is extremely important because the volumes of seasonal change are very large— we need to know if these changes are real or error.
4-29/3/10: The net depletion in Central Bay is not 2.6 million cy according to Table 4-4. Table 4-4 has net depletion as 26 million cy. Is the table correct and this is a typo? This "typo" appears in the text several other places and the 2.6 million cy is used in a crude sediment budget later in the report.
4-29/3/last sentence: Typo: change July 2002 to Jan 03.
4-29/5/5: Typo: change deletions to depletions.
Table 4-4: There is an interesting seasonal signal in this data from Central Bay that is not pointed out in the report. From January to July, there is net sediment loss of sediment, while, from July to January, there is net sediment accumulation. One explanation of this is input of river sediment form January to July and subsequent erosion from July to January. However, the volumes are large, perhaps larger than expected for this process (numerical sediment transport modeling could constrain this). The largest and second largest volumes of accumulation also correspond to the largest and second largest calculated delta outflows (Fig. 4-62). This supports that changes were caused by a river source of sediment because the sediment delivery increases as a higher power of the flow velocity.
Table 4-5: A similar, but more complicated, seasonal trend is apparent in the North Bay data as in the Central Bay data. This data, since it includes non-mining areas, can be analyzed for non-mining effects. The largest sediment accumulation, which is primarily sediment from the Sacramento and San Joaquin Rivers, is from January to July 2000. Again, this combined with the data from Table 4-4, suggests that

large volumes of sediment from the Sacramento and San Joaquin Rivers are deposited in Central Bay.
Table 4-6: The signs on the values "Change in Depth" column appears to be incorrect from other data in the report. Is this true? The mining volumes are from a different time period than the net change volumes. They should be from the same time period. Even though the time periods are not the same, it is interesting to note that the largest changes in depth occur in the areas with the largest sand mining volumes (6, 10, 20).
4-31/3/2: Sand transport during river flood stages is primarily as suspended load. See Porterfield (1980) for data on the Sacramento and San Joaquin Rivers.
4-31/3/3: During floods, sand is deposited in shallows (sand layers in cores taken in the western part of San Pablo Bay, Allison et al., 2003), not only in the channel.
4-45/2/all: Onshore transport from the ocean to the bay certainly does occur to some extent. The question is, "How significant is sand transport from the ocean relative to river sources and relict sediment?" The "mirror bar" hypothesis needs to be better supported before adopting sand transport on flood tides as the accepted primary mode of sand delivery to Central Bay. There is supporting evidence for net transport of sand from the ocean to bay that the report did not cite. Rubin and McCulloch (1979) determined that asymmetry in bedforms indicated a net bayward transport from the ocean, although they did not quantify the rate of net bayward transport. Rubin and McCulloch (1979) also present current meter data that show. East of the Golden Gate, there were stronger flood flow velocities than ebb flow velocities. Stronger flood flow velocities results in net sediment transport into the bay because transport increases as a higher power of the flow velocity. A simple "mirror bar" is not likely to be present in San Francisco Bay because there are two channels inside the Golden Gate that would result in flood tidal currents that have a different geometry than the ebb-tidal jet.
Figure 4-17a: According to Chin et al. (in press), sand mining effects on Point Knox Shoal are apparent in multibeam data. This appears in Fig. 4-17a.
6-1/4/all: For at least parts of the bay, the statement that "sand mining activities remove sediment from the estuarine system, in effect partially and locally offsetting the overall anthropogenic acceleration of the long-term natural trend" is not correct. For example, data from Cappiella et al. (1999) indicate that, from 1867 to 1990, there was net erosion (99 million cubic meters) in the Suisun Bay region (including Honker Bay, Grizzly Bay, and Carquinez Strait). The long-term trend in the Suisun Bay region is not filling, but loss of sediment. Even in San Pablo Bay, which filled at a rapid rate during the hydraulic gold mining period (Jaffe et al., 1998), is now loosing sediment—not filling.
6-8/5/all: A question not answered in this report is, "Is the San Francisco Estuary sediment limited?" If not, mining sand would have less of an impact. If the system is limited by the amount of sediment, and sand in particular, then any activity that removes sand (sediment) from the system will have an effect somewhere in the system.
6-10/4/last sentence: The purpose of Cappiella *et al.* (2001) [sic], Jaffe *et al.,* (2001) [sic], Ogden Beeman and Krone (1992) and USACE 1967 was not to quantify the effect of sand mining. It is faulty logic to say that "None of these studies has identified sand mining as a causative factor in changes to these features, so, on the basis of the literature, any such potential impact due to sand mining appears to be negligible, at least over a geologically short period of 50 to 70 years."
6-11/1/1: According to Chin et al. (in press), sand mining is detectable in multibeam data at the local scale on Point Knox Shoal. This appears in Fig. 4-17a.
6-11/3/2: Typo? 2.6 million cubic yards (should it be 26 million cubic yards as in Table 4-4?) If so, how does this change your statement of, "this net depletion rate is approximately what would be expected from a net mining of about 1.2 million cy/year (3.6 million cubic yards total) and a replenishment rate from the San Francisco Bar of 315,000 cy/year (945,000 cy total – Battalio and Trivedi, 1996, estimate)."

6-13/1/12: "Results of a series of analyses conducted by comparing channel margins and bathymetric contours within Suisun Bay and Central Bay between 1975 and 2001 are presented in Section 7.9. Results of these analyses did not show a significant pattern of changes in depth contours for shallow-water habitat along the channel margins within either Suisun Bay or Central Bay." What is significant change in shallow-water habitat? How was this determined? Note: Comparisons of navigational charts is flawed because of data bias and tendency to not update data (see Summary comment #4).
6-14/3/4: Gilbert (1917; pg. 67) assumed that "a period of 50 years will close, for the rivers, the history of hydraulic mining debris of the last century." He also shows a decline of delivery of debris to bays starting in approximately 1900, which if projected into the future, would result in very low delivery rates of debris in approximately 1950 (Figure 5, pg. 39). What evidence is there for the statement, the removal of sediment by mining "appears to be overwhelmed by the ongoing after-effects of the sediment pulse from hydraulic gold mining in the late 1800s?"
6-14/4/3: Typo? 2.6 million cubic yards (should it be 26 million cubic yards as in Table 4-4?)
7-75 and 7-76 (Habitat Change): This analysis is flawed because it uses navigational charts. Comparison of charts will tend to show less change than actually occurred because data is from mixed years (two charts made decades apart will the same sounding values—from a H-sheet made before the earlier chart). See Summary comment #4 for more using navigational charts as a source of bathymetric change.
6-76/3/13: Figures mislabeled—there are two Figure 7-51.
8-12/bullet 2/ last sentence: The statement that sand mining has not "resulted in changes in water depth or subtidal habitat conditions that individually, or in combination with other factors, significantly degraded subtidal habitat conditions" requires a definition of "significantly degraded" to be evaluated. It has not been shown in this report that there have not been water depth changes related to sand mining.
9-4/2/3: I doubt that survey methods and protocols have changed enough to add more than a few centimeters of error, unless the surveys were done improperly.
9-4/2/10: Typo. See Tables 4-5 and 4-5.
9-5/section 9.2.2 (Determination of the Precision …): Future surveys should have trackline crossing (tracklines that cross other tracklines) to give independent estimates of depth. These independent estimates may be used to estimate survey error.
9-8/section 9.3 (Sediment Dynamics/Sediment Budget): Sediment traps are difficult to deploy, have uncertain efficiencies, and do not work well in high-energy environments. A better approach to determining sediment movement patterns and volumes of transport is to use a numerical coupled 3D hydrodynamic/morphologic/sediment transport model. There are several such models that exist (e.g., Delft3D) that could improve the understanding of the sediment dynamics and sediment budget.
9-10/section 9.4 (Reference Sites): I agree that reference sites are needed. Complete bathymetric survey coverage less frequently, or perhaps a nested scheme, would document how non-mining areas changed for comparison with mining areas. This baseline is very useful for determining non-mining effects.
9-10/ section 9.4 (Reference Sites): I would expand the concept to include reference conditions. Reference conditions could be established using historical data. For example, change detectable from hydrographic surveys from the 1800s and 1900s could be used to learn the behavior of the system.
Section 9: The Recommendations for Additional Studies section does not consider the value of studies that exploit information that can be learned from bay-floor sediment properties. These include: (1) quantifying temporal and spatial variation of bay floor sediment grain size, and (2) provenance of sand. The grain size information will aid in improving the understanding of sediment dynamics and sand budget. Collection of grain size data at the same time that bathymetric surveys are conducted will help understand the seasonal (and longer term) fluctuations in net

sedimentation (i.e., is sand or mud deposition and erosion causing the volume fluctuations observed in the surveys). Grain size data in habitats of concern will quantify the contribution of sand to maintaining the habitat. Provenance studies will help determine the source of the sand (ocean vs. river; specific rivers) and also improve the understanding of sediment transport pathways.

REFERENCES CITED:

Allison, D., Hampton, M., and Jaffe, B., 2003, Preliminary analysis of cores from North San Francisco Bay, California-Project description and example of data sets: U.S. Geological Survey Open-File Report 03-113. URL: http://geopubs.wr.ussgs.gov/open-file/of03-111/index.html

Burau, J.R., Simpson, M.R., and Cheng, R.T., 1993, Tidal and residual currents measured by an acoustic Doppler current profiler at the west end of Carquinez Strait, San Francisco Bay, California, March to November 1988: U.S. Geological Survey Water-Resources Investigations Report 92-4064, 76 p.

Cappiella, K., Malzone, C., Smith, R., and Jaffe, B., 1999, Sedimentation and Bathymetry Changes in Suisun Bay: 1867-1990: U.S. Geological Survey Open File Report 99-563. URL http://geopubs.wr.usgs.gov/open-file/of99-563/

Chin, J.L., Wong, F.L., Carlson, P.R., in press, Shifting shoals and shattered rock—how mna has transformed the floor of west-central San Francisco Bay. US Geological Survey Circular 1259, 42 p.

Conomos, T.J., 1963, Geologic aspects of recent sediments in south San Francisco Bay: Maters Thesis, San Jose State University, 118 p.

Gilbert, G.K. 1917. Hydraulic-mining debris in the Sierra Nevada. USGS Professional Paper 105. 154 pp.

Hampton, M. A., Snyder, N. P., Chin, J. L., Allison, D. W., and Rubin, D. M., 2003, Bed-Sediment Grain-Size and Morphologic Data from Suisun, Grizzly, and Honker Bays, CA, 1998-2002: U.S. Geological Survey Open-File Report 03-250, 25 p. plus 1 plate. URL: http://geopubs.wr.usgs.gov/open-file/of03-250.

Jaffe, B.E., Smith, R.E., and Torresan, L., 1998, Sedimentation and bathymetric change in San Pablo Bay, 1856-1983: U.S. Geological Survey Open-File Report 98-759. URL http://geopubs.wr.usgs.gov/open-file/of98-759/

Locke, J. L., 1971, Sedimentation and foraminiferal aspects of the recent sediments of San Pablo Bay: Maters Thesis, San Jose State University, 100 p.

Ogden Beeman and Ass. and R.B. Krone and Ass. 1992. Sediment budget study for San Francisco Bay, final report. For San Francisco District Corps of Engineers. February 1992.

Porterfield, G., 1980, Sediment transport of streams tributary to San Francisco, San Pablo, and Suisun Bays, California, 1909-66: U. S. Geological Survey Water-Resources Investigations 80-64, 92 p.

Sternberg, R.W., Cacchione, D.A., Drake, and Kranck, K. , 1986, Suspended sediment transport in an estuarine tidal channel within San Francisco Bay, California. Marine Geology (71), p. 237-258.

Rubin, D.M. and D.S. McCulloch. 1979. The movement and equilibrium of bedforms in Central San Francisco Bay. Pp 97-113 *In* T.J. Conomos (ed), San Francisco Bay – The Urbanized Estuary. Pacific Division Amer. Assoc. Advance. Sci. San Francisco, CA.

Document: "Assessment and evaluation of the effects of sand mining on aquatic habitat and fishery populations of Central San Francisco Bay and the Sacramento-San Joaquin Estuary"

Reviewer: Robert B. Spies, Ph.D.

Reviewer Qualifications: Ph.D. in Marine Biology, University of Southern California; 34 year's experience in detecting man's effects in coastal and estuarine environments; 50 publications; Editor, *Marine Environmental Research*

Scope of review: Reviewer has focused on biological and chemical aspects of the report. Reviewer does not have expertise in geological processes and acoutics and leaves those aspects to other peer reviewers.

General Comments:

I have some general comments about how this document is organized and presented. My perspective is a purely scientific one, not as one who is reviewing the document to see how well it functions as an EIR. That is, I am looking primarily for a logical presentation and analysis of the problems and their significance that I can assimilate and make judgments about. Therefore, I want to know: How are the problems presented? What is the approach used to solve the problems? What are the standards of proof used to come to conclusions about effects? How are the analyses presented? Is the document approachable by agency personnel and the public?

1. This document is very generally professionally and competently done. It is thorough. The potential problems of sand dredging have been identified. The appropriate literature and study results have been considered. New and extensive analyses have been done. The writing is clear and the figures support the text. The conclusions are largely reasonable based on the analyses that have been done.

2. Presentation. This document is not user friendly. It is huge. It is packed full of information, more information than one needs to do a basic analysis of the environmental risks of sand dredging. The amount of information included in the document gets in the way of the reader who wishes to understand the main risk factors associated with sand dredging. For most of the presentation one must wade through literature reviews, detailed accounts of findings from various studies, ancillary but non-essential data, and methods of analysis to get to the essential elements of risk analysis and interpretations of findings. Also the presentation includes too many layers of organization and it is not easy to stay oriented as one negotiates through looking for the crucial information. (An example of a buried gem is found on p, 7-17 where it is stated that Wilbur and Clarke (2001) found the threshold for effects for sensitive species is 100 mg/L for 24 hours). Its mere size makes it intimidating and bewildering to any reasonable person who is trying to obtain a general understanding of the risk of continued sand mining to the estuary ecosystem. I know that this is the usual style of an EIR, but that does not make this document any easier to assimilate. There ought to be serious consideration given to either: 1. Moving much more of the material in the main body of the document into the appendices so the main flow of the analyses can emerge from the swamp of detail they are now mired in, or 2. Making an extended technical abstract that distills the crucial elements of an ecological risk assessment and presents them in a concise manner with references to supporting material in the text and appendices. As it is, the serious and critical reader is confronted with a commitment of time and energy that seems unnecessarily large. I am convinced that the essential arguments that are made in this EIR could be communicated in the space of several hours of the reader's time (or in an extended afternoon seminar) and not the several days it takes to wade through this document.

3. Use of appropriate data. In several places in the document there are problems framed for which the data relevant to sand mining are minimal or entirely lacking. Then study results that are tangentially related are introduced, discussed, and eventually discarded because they are not relevant to sand mining. (Usually because of differences between maintenance dredging of harbors and sand mining --e.g., on p. 7-30 to 7-32, due to differences in the fines content of the dredged material). It seems in these cases that much of this could be removed from the text and replaced with simpler statements, preventing the reader from following false leads in the logic of the presentation and losing the thread of the risk assessment.

4. Standards of proof and terms of reference. I did not see any discussion of what standards of proof were to be used in forming conclusions. This is not usually done in an EIR, but it is crucial step if one is discussing the potential impacts of specific activities in complex environments, where cause and effects are not easily interpreted. Is a lack of proof of a population-level impact the standard by which impacts are judged? That is, can it be concluded that there are no effects in the absence of population level effects? To what extent does the precautionary principle come into play? Is there a middle ground between proven population level effects and extreme application of the precautionary principle? Discussion of these standards at the beginning of the document would make this philosophically tighter, especially if such standards were followed throughout the analysis. There are places where the lack of evidence of population level effects seems to be the standard for concluding there are not effects.

5. Formulation of conclusions—There are many places in the document where issues are raised, literature results are brought to bear and perhaps new analyses done to address the issue, but in the end some sort of professional judgment is invoked and a qualitative statement is made effects. I would recommend looking once again at major areas where this is done and see if more definitive quantitative statements can be made. One example of this occurs on p. 7-26 where conclusions are drawn about the overall significance of plume avoidance. It ends in a general

professional opinion, where careful reference back to the findings of important studies would be stronger. Another example is found on p. 7-49, where at the end of a long section on potential dredge entrainment effects, including use of a quantitative analysis, the section ends with "…however based on the results of the equivalent adult analysis, the magnitude of the icthyoplankton entrainment is not expected to result in adverse impacts to regional populations of these species." More specific proportions or percentages of the entrainment effect carried forward to the conclusion would be a big improvement.

Other comments

1. Does Chuck Hanson have any relationship to Hanson Aggregate? Any financial or familial ties should be noted in the document.

2. Linking the conceptual models in Figures 7-1 and 7-2 with particular portions of the text would be helpful. This could also be a road map that is repeated with a different part of the model highlighted at the start of each section of the text to help orient the reader to what particular aspects of the impacts are being analyzed next.

3. In Figure 1 and in some other figures (e.g., 2-18) the meaning of the symbols is not provided. That is, what do the red circles mean? I assume they are locations of mining activity, but this is not stated.

4. In Fig. 1.b.2 there is no mining area shown.

5. Figures 7-10 and many others (that appear to be copies out of the original papers and reports) in section 7 are poor quality.

6. The scale of TSS for Figs. 7-14, 7-16 and many subsequent figures needs to converted to log scale to be able to see the actual values of the data in the lower range of the graphs. Are the B panels blow-ups of the A panels—if so this should be noted in the captions. In Figs. 7-13 through 7-16 and subsequent figures in section 7 it would be good to identify the species that seem to be the most sensitive to TSS effects.

7. Fig. 7-18 should have a log scale for TSS.

8. Table 7-5 Caption needs the addition of text describing what is being tested.

9. Table 7-21. What are the units for entrainment rate?

10. Table 7-63. The wet weight biomass values should be expressed on an areal basis, e.g., g/m^2.

11. In section 7.7.3, which deals with entrainment effects on fish, the conclusions are not very satisfactory, referring to the difficulty of being able to believable analyses, and the difficulty in projecting losses to the population level. Yet, in other parts of the report there are attempts to overcome such difficulties an at least come up with a worst case scenario.

12. On p. 7-35 it is stated that metals liberated from sediments during dredging are soon bound to particles and the assumption is that such compounds are not a toxicity problem in the plume. The fact is metals exist in an equilibrium state with particles. In sediments there can be more metals in an unbound form in pore water and the equilibria will depend on geochemical conditions. Dredging can liberate ionic metals that reach new equilibria with particles in the water. However, they can still exert toxic effects, especially if they are ingested by filter feeding animals.

13. On p 7-36 it is stated that contaminants do not bind to sand, which is not totally accurate. They bind, but much less so than to clay particles.

14. In section 7.12, which analyses the monthly trawl results from the CDF&G delta outflow program with regard to the potential effects of sand dredging, is a good example of where marginal analyses are done and in the end are not useful for the reader. Obviously the CDF&G program was not designed, either in its temporal or spatial sampling, to answer questions about sand mining effects. Any reasonable scientist could see that the design is inappropriate and not dependable for drawing any conclusions. I suppose that including several pages of preliminary analyses of the data in the text might help satisfy skeptics that you are not hiding something, however it is just more irrelevant "stuff" to wade through.

15. Regarding the evaluation of benthic effects. I believe that this is where the most significant impacts of sand dredging will occur. It also seems that a fair amount of quantitative effort was put into other areas of impact relative to what was done for the benthos. I believe that a more thorough quantitative analysis of the effects of dredging on the benthos could be done given the scope of the effort. A number of assumptions could be made. For example, one could make an estimate from the literature of the potential length of time after dredging that disturbances would last, estimate the surface area of sandy bottom that is disturbed in each dredging area and express the impacts in terms of lost production in the sandy bottom habitat of each estuary segment. Assumptions would have to be made at each step, but at least the potential scope of the quantitative impact could be made in a worst-case mode. Part of the information needed to make such an assessment is included (e.g., in Table 7-63).

16. The incremental effects section is generally quite weak. Incremental effects are difficult to approach and there is no clear and definitive way to do this. Perhaps it would help the clarity of the document just to acknowledge the difficulties from the outset.

Agency Review Comments

Page 1 of 1

Subj:	**Re: Sand mining draft technical report status**
Date:	12/10/03 10:17:44 AM Pacific Standard Time
From:	OetzelD@slc.ca.gov
To:	CHansonEnv@aol.com
CC:	HOWEM@slc.ca.gov
Sent from the Internet (Details)	

Hi Chuck,

Is there a acronym listing in the study? Also, the head of our Land Management Division asked if there was a glossary? For example, "Franciscan chert" will probably not be in most of our personal lexicons.

Thanks.

Donn

Subj:
Comments on Sand Study

Date:
3/12/04 10:32:26 AM Pacific Standard Time

From:
OetzelD@slc.ca.gov

To:

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File:
SandMiningReport,HansonEnviron,REVIEWOF.doc (66048 bytes) DL Time (TCP/IP): < 1 minute

Sent from the Internet (Details)

Please find my comments attached regarding the Hanson Environmental draft sand report (December 2003). With respect to this report, my role at State Lands is to primarily focus on those aspects that could have a future economic impact on sand mining in the San Francisco Bay estuary. Therefore, my comments are centered primarily on the geological aspects of the report. However, because potential environmental impacts may have an influence on the economics of sand mining, I have also reviewed and in some cases commented on some of the sections of the report that discusses potential biological impacts. Comments on an environmental topic such as biology are preliminary in nature and will be more fully addressed in the required CEQA document for the project.

Donn Oetzel
California State Lands Commission

March 12, 2004

Review of Hanson Environmental Inc.'s Sand Mining Report

p. ES-2: Based upon my reading, there were in fact some field studies done by the geologist regarding potential sand sources (See section 4). You might as well credit yourself where credit is due!

p. ES-3 on Project Purpose:

No mention of State Lands as the landowner. Also, our agency is going to evaluate more than the biota (the adverse impacts named in the bulleted items). We are also interested in the history, depletion and replenishment rates of sand in the Bay estuary independent of impacts on biota.

Section 2.2. Description of Sand Mining Equipment and Methods.

p. 2-6, 3rd paragraph. It is noted that aggregate larger than the opening in the screens is discharged overboard. Given the screen size, what is the minimum grain size that is discharged overboard? Given the equipment limitations, what is the maximum grain size that is discharged overboard? Is there any information available on the volume of aggregate that is discharged overboard on each mining episode?

p. 2-7, 1st paragraph. How do the cutter jets discussed on p. 2-6 fit into the description of the sand mining process given in this paragraph? It would be helpful if cutter jet technology and methodology were integrated into this description of the sand mining process. Do you have a photograph that clearly shows the cutter jets?

Section 2.0. Figures and Tables.

This section is incorrect in some areas and incomplete in others.

Section 4.1.3. Grain Size of Sand Samples, p. 4-3, 4-4.

Clarification is needed on Table 4-1 and Figure 4-4. Are these exhibits based on the same two samples? If so, why don't they correspond with one another? There are different percentages shown for the same grain size, e.g. Table 4-1 has Central Bay sand having 22.7% medium grain; Fig. 4-4 shows there to be approximately 10% medium grain in Central Bay.

What is the source for Fig. 4-4? How many samples? Where were the samples taken?

Table 4-1 does not have the label "eastern zone," yet reference is made to an "eastern zone" of Table 4-1 in the text on p. 4-3. Is Suisun Bay (Sand B) synonymous with the eastern zone, and vice-versa?

It would be helpful to have a table of grain size data exhibiting the data referenced from the San Francisco International Airport study. The number of samples and locations would also be helpful. A color-coded map showing sand grain types in the Bay estuary would be helpful.

Reference is made to Appendix D. For interpretation purposes, it would be helpful to map the locations noted in the SFEI study and then note the sand type areas (fine, medium, coarse, etc) in a color code. It would be helpful to have the full name instead of the acronym SFEI on the title for Appendix D.

Mention is made of Table 1-B. Where is it located? It is not in section 1 and I see no mention of it in List of Tables.

It would be helpful to have the ADEC information in this section in the form of color-coded map.

4.1.4, p. 4-4. Rock Type and Physical Descriptions of Sand Samples

What percentage of the Central Bay sand is angular, subangular, subround and round?

Mention is made of "Franciscan chert pebbles", "Calera limestones" and the "Franciscan formation" in this section. It would helpful for there to be a glossary explaining these terms or for an explanation immediately after these terms are introduced rather than later in the report.

p. 4-4, 4-5

What percentage of rock types are the same for both the Central Bay and Suisun Bay?

4.1.5, p 4-5, 4-6. Sediment (Particularly Sand) Transport Dynamics (Sources and Sinks)

The bottom of p. 4-5 and top of p. 4-6 reads, "…other scales and descriptions (of grain size) also exist in the literature and are used by the industry as shown in Table 4-16." However, Table 4-16 depicts SFEI water quality statistics. Is there a corresponding Table reference for the sentence noted above?

P. 4-6, 2nd paragraph. This discussion of sediment discharge, which includes the 1992 Beeman & Krone study, should include figures from DMMO on dredging and the trend in the past few years of taking more sediment out of the system (to deep ocean disposal site or upland). In addition, Dr. Bruce Jaffe (peer review committee) may have recent information (since 1992) on a net sediment deficit in the Bay estuary.

Second to last paragraph of 4-6: Is the "*unconsolidated sediment*" of the San Francisco Bar simply sand? Have samples been taken of the Bar showing the percentages of grain size? If so, it would be helpful to introduce that data when writing about the Bar.

What is the surface area of the Bar? What is the depth of the Bar? What is the volume of the Bar? How much of the Bar's sand source is from upland areas of drainage (Sierra's, etc.)? How much of the sand at the Bar comes from the Pacific Ocean? How large was the Bar at its historical peak? At it's low?

4.1.6, p. 4-6 through 4-12. Geologic Setting of the San Francisco Bay Estuarine System.

Given the fairly recent DMMO policy of emphasizing the removal of sediment from the system and Dr. Jaffe's comments, which may include the impact of damming of upland water sources and the attendant byproduct of withholding sediment from the system, there may be a recent trend of net depletion of sediment in the estuary. It would be helpful to note the facts regarding this hypothesis. If the hypothesis is correct and it is a recent geological trend, what significance, if any, does it have for sand mining? Is less sediment or more sediment in the estuary a "good" environmental condition? Are there as many environmental "losers" as there are "winners" with net erosion or net accretion?

p. 4-7, **Faults.** From discussion later in the section, it appears that one significant feature of faults is: faults → earthquakes → tsunamis → periodic sand replenishment within Central Bay. It would be reader-friendly to state the significance of faults at the very beginning of the section.

p. 4-7, 3rd parag. "(lease 7781; Fig 1-2)" is noted. Fig. 1-2 should be plainly labeled 7781 (in addition to the West Suisun Associates label and East Suisun Associates label). The reference on p. 4-7 should be Fig 1-2***d***.

p. 4-8, 2nd parag. What is significance of the sand deposits interlayered with finer material that may extend to great depths beneath eastern San Pablo Bay? When estimating total sand volume in the Bay, is the sand in the interlayered deposits included?

p. 4-8, 3rd parag. Describe "warping deformation." How often has this "active deformation" altered the riverbed shape to influence the location of commercial sand deposits? Are we talking tens, hundreds, or thousands of years? What is the significance?

p. 4-8, second to the last and last parag. It would be reader-friendly to describe the Franciscan formation and chert when it is first introduced in the report– section 4.1.4.
p. 4-9, 1st parag. Of the samples of Central Bay sand, what percentage is Franciscan chert?

p. 4-9, last parag. Please clarify: "The sedimentary fill of the graben is up to 330 feet thick…" "This thickness where the Bar crosses the graben is approximately 200 feet…." The discrepancy is confusing. Does this mean that the Bar thickness is 200 feet on top of the 330 feet deep sediment of the graben fill, with a total sediment depth of 530 feet? Is all this sediment sand?

p. 4-10, last par., p. 4-11. What is the volume of the Bar currently? What has been the volume of the bar in past years? Is there a statistical correlation between the tidal flow volume and velocity (tidal prism) with Bar sediment volume?

p. 4-11, 4th parag. A diagram of the Bar showing grain size distribution would be helpful.

p. 4-12, 4th parag. Figures 4-12.4 and 4-12.6 should be 4-12a and 4-12b.

4.1.9. Coastal Areas.

p. 4-15, 1st parag. Is there any record of tsunamis carrying major sediment from the Pacific Ocean into San Francisco Bay?

p. 4-17, 3rd parag. As I understand it, of the sand transported inward from the Pacific Ocean to Central Bay, zero to 100,000 cubic yards per year comes from Ocean Beach and the San Francisco Bar. How much sand is estimated to in Central Bay is estimated to come from the Marin Headlands?

p. 4-17, 4th parag. How does weather, especially significant storms, fit into this picture of the sand budget?

p. 4-18, 1st parag. Regarding Best and Griggs (1991), what is the significance of the Santa Cruz littoral cell terminating south of the Golden Gate? How does that affect sand transport along the coast or in Central Bay? How does that make for a different picture than Habel and Armstrong (1977) with respect to sand movement?

Figure 4-17a and 4-17b. What is the date that the "snapshots" were taken?

4.2.1. San Francisco Bay – Morphology.

p. 4-20, 1st & 2nd parag. Do the 'upper' flat beds contain sand? Do the 'lower' flat beds contain sand? How can one tell the difference between the 'upper' and 'lower' when looking at a multibeam backscatter image as seen in Figure 4-17a and 4-17b?

p. 4-20 It would be helpful to circumscribe the 'cratered' area and the "hummocks" in Fig. 4-17a.

p. 4-20, 4th parag, Fig. 4-17a. What is date of the first record of the 'pocked' area?

4.2.5. Anthropogenic Factors Affecting Bay/Delta Sediment Dynamics (Gold Mining, Reservoir Impoundments).

p. 4-23, 2nd parag. What was the time period during which 1,300 million cy of sediment was deposited in the Bay estuary?

p. 4-23, 4-24. It would be helpful to have a bar chart or graph showing the net accretion or erosion of sediment in the Bay estuary from the mid-1880s to present day.

Is less sediment or more sediment in the estuary a "good" environmental condition? Are there as many environmental "losers" as there are "winners" with net erosion or net accretion?

Did the hydraulic mining cover sandy areas of the San Pablo Bay with mud, or did it just add to the mud that was already there? On p. 4-24, 4th parag. mention is made that the south bay is mostly mud over sand. Did the mud come from the hydraulic mining? On p. 4-8, 2nd parag. there is mention of the interlayering of sand and mud. Did the hydraulic mining cause this? Did the hydraulic mining contribute to less of a sandy surface area in the Bay? If so, how much less?

p. 4-25, 2nd parag. Fig. 4-21a. It would be helpful to state on this map what is stated in the report: from 1955 to 1990, the total net change for the *entire* area was 37.64 million cy of accretion, equivalent to an average shoaling of 1.25 feet.

The statement, “However, much of the shoaling appears to have occurred east of Angel Island (Figure 4-21a),” is confusing. Based on my inspection of the figure, there is relatively little shoaling shown east of Angel Island. In fact, there is relatively little area shown east of Angel Island on this particular map. Is this the entire map? It would be helpful include a legend for distance.

Also confusing is the statement, “For the Central Bay sand mining areas, however, the pattern is more complex with areas of both accretion and depletion of more than approximately 6 feet, as shown in Figure 4-21a-b.” First, Figure 4-21b refers not to Central Bay, but to Suisun Bay. Second, there is no discussion of patterns when referring to the cited sources. Third, the Central Bay sand mining areas are more complex than what? The author appears to want to make a distinction between the accretion/erosion totals for the areas cited in two studies and for that of the leased areas. In that regard, it would be helpful at this junction to note the total accretion/erosion for all leased areas in Central Bay; then to note the same for that of Suisun Bay. Then a comparison can be made between the Ogden Beeman (1992) study and the USACE (1967) study with the total accretion/depletion in the Central Bay lease areas.

Figures 4-21 b, p. 83-84. It would be helpful to note on these maps what the total net accretion or depletion was for these areas from 1955-1990. It would also be helpful to restate that fact in the report.

p. 4-25, 3rd parag. Why is a “net balance” difficult to calculate for sand mining areas during the 1955-1990 period? The Ogden, Beeman and Krone (1992) study determines a net accretion in the larger Central Bay area from 1955 – 1990. By what mathematical/statistical methods did Ogden, Beeman and Krone determine that there was net accretion of 37.64 million cy (1955-1990)? Could the same methods be utilized to calculate a net balance for the lease areas after overlaying them with the Ogden, Beeman map? Do the authors of the cited study have raw source material (a digital map? A more detailed map?) that could be helpful in this regard? The Ogden study did not differentiate sandy substrate areas from those areas that are not sandy. Is there a way to refine the Ogden data to measure only sandy substrate areas?

p. 4-25, 4th parag. The Study states: “Within Central Bay, results of these analyses suggest that sediment depletion occurred within a number of the areas where mining activity appears to be most concentrated, based on mining log information compiled for the period from March 2002 through February 2003.” First, what evidence supports the belief that the mining locations shown on Fig. 4-21a (March 2002 – Feb. 2003) are indicative of the mining locations over the past five decades? Also, the Executive Summary states (p. ES-5): “During the course of the investigation, however, changes occurred in the geographic locations where a portion of the sand mining activity occurred, particularly within Central San Francisco Bay that may have contributed to potential changes in the affects of sand mining activity when compared to historic operations.” Might not that one factor weaken the inference that last year’s mining locations are indicative of prior mining locations? Based on the data presented, it would seem that it might be more appropriate to say that the miners happened to mine last year in areas that were depleted during the 1955 – 1990 time period, rather than to draw a conclusion that depletion occurred in areas where mining appears to be most concentrated.

4.2.6. Changes in Bathymetry Resulting from Sand Mining on a Regional and Local Scale.

p. 4-27, 3rd parag. The Study states that increased water diversion is expected to have minimal overall impact to sand transport in the upper part of the estuary because tidal currents are dominant. However, the Study has made a point that tidal currents are a pivotal factor in Central Bay, not Suisun Bay. Are tidal currents the dominant factor in bedload transport in Suisun Bay? If not, would one expect that a decrease in water flow would decrease the amount of sand replenishment in Suisun Bay?

p. 4-27, 4th parag. What is the surface area of the sandy substrate in Central Bay? Knowing that number, how does it affect the calculation shown?

p. 4-28, 1st and 4th parag. Further discussion on transect interval width would be helpful, especially the reasons for there being such a wide range of interval width (70 – 500 ft). The 500 foot interval has been the interval discussed in our sand meetings. The Army Corps permit stipulates 100 foot transect widths. The State Lands and BCDC has stipulated 500 foot intervals, notwithstanding BCDC’s recent permit renewal of 709 that stipulated 250 foot intervals.

p. 4-28, 2nd paragraph. Please inform us which episodes of which sand lease areas did not appropriately cover the lease areas.

Also, please inform us when the sand lease areas were redefined. Is there a method to compare the depletion/accretion of the redefined survey areas with the previous survey areas in an "apples to apples" manner?

4.3.1. Distribution of Sand Resources.

p. 4-33, 3rd parag. The second sentence needs to be rewritten.

Fig. 4-49 on p. 111. I cannot distinguish between the color of fine sand and that of the fine-medium sand grain size. Is it possible to use different, more distinct colors?
Also, all the grain size categories seemed to be grouped together, with the exception of medium-coarse sand. In many cases, the medium-coarse sand seems to be in very close proximity to the silts and clays, at the lowest end of the grain size range. Is there any explanation for this pattern?

Fig 4-50, p. 115. The colors of gravel and sand are indistinguishable from each other.
Also, I do not understand how areas surrounded by large blue dots (e.g. East Bay with 60 million cubic yards) are not also colored yellow. Please explain the discrepancy.

Fig 4-49 through Fig 4-54. It would be very helpful to have the outline of the lease areas overlying these Figures.

Fig 4-54. Why is that sand waves are seen in lowest velocity areas (green and yellow) and they are not seen in higher velocity areas (orange and red)?

p. 4-33, 1st sentence, last parag. Comment needs to be made here about sediment coming in from the ocean. Does this sentence refer to both sediment coming in from the ocean and sediment coming from the Sierras?

p. 4-35, 3rd parag. The report states: "Figure 4-55 demonstrates the correlation of the areas of mining activity and the sand waves on the floor. Figure 4-55 is indicative of the relationship between the peak flow velocities, the locations of harvestable sand and the presence of sand waves on the bay floor created from high flow rates" Does it? The map seems to show a significant amount of mining occurring southwest of Angel Island in a yellow area (depth-averaged peak velocity of 125-150 cm/sec) that is characterized by the "pocked" markings that was referred to previously in the report. This "pocked area" is distinct from the area marked by sand waves. However, both the "pocked area" and much of the sand wave area is colored yellow on Figures 4-54 and 4-55, indicating that the velocity of the areas are similar. Based on the report, the sand waves are a function of current velocity. Then why aren't there sand waves in the "pocked area"?

The incongruity of the maps and the explanation provided raises many questions. If the sand on the surface were 'cemented' or a much larger grain size than that found in the wavy areas, the explanation would make more sense. A current of the same velocity as the sand wave areas would not yield the same wave effect under those circumstances. Or, possibly there is a much slower current near the substrate level than near the surface relative to the sand wave areas, even though the average velocity is similar to sand wave areas. See Figure 4-12a and 4-12b. Ebb tide shows two arrows (one large, one medium) heading toward pocked area. The report indicates sand is brought into this area via the ebb tide. So, one would expect sand waves, not pocks. What is also interesting is that the flood tide doesn't have arrows in this area. Based on the Figures, the conclusion that can be drawn is that there are higher velocity currents bringing the sand into this area than there are taking the sand out through the Golden Gate. The net result should be consistent sand deposition.

Testing of the grain size on the surface of this pocked area would be helpful. Additional historical research on the origins of these pocks would also be beneficial.

4.3.2. Sediment Volume.

It would be helpful if this entire section is rewritten. To be reader friendly, please tell the reader where you are taking him, take him there, and then summarize. Indicate the significance of "sediment volume." If sand, not sediment volume, is the relevant topic, start with the heading "Sand Volume." It would be helpful to define what is meant by "sand volume". Page 4-4 defines sand as 90% of the material having grain sizes between 3/8 inch and 0.075 mm. Is the definition of sand volume therefore a volume of space that contains sedimentary material with an average of 90% having grain sizes between 3/8 inch and 0.075 mm? Is the same definition employed in the three noted studies – Goldman, ADEC and USGS? If so, please elaborate for this section.

What are the potential issues surrounding the definition of "sand volume"?
Conceivably, there could be two adjacent areas of identical size. The first area consists of 85% grain size between 3/8 inch and 0.075 mm to a depth of 90 ft from the surface (mineable depth) and the second area consisting of 95% of the same grain size range to mineable depth. The total area has an average of 90% of the material having a grain size between 3/8 inch and 0.075 mm and is therefore considered "sand" for purposes of this report. However, only half the area is above 90% "sand" and is therefore marketable. How does the author and the quoted studies in this section handle this problem? How does Fig. 4-56, which shows as much as 18% silt and clay fit into the definition of sand for the analysis? How does Fig. 4-4, which shows no silt or clay, compare with Fig. 4-56? Why the difference?

What is the significance of sand volume for the purpose of this report? This issue is raised at the end of Section 4.3.2 (p. 4-38, last paragraph). It would be helpful to the reader to introduce points of significance at the beginning rather the end of the section. One point of significance and emphasis may be the depth to bedrock. Environmental impact is certain to occur at that point. A second point of significance is that only by knowing the current volume of sand in both the shoal areas and the lease areas can judgments be made regarding depletion or the rate of mining that should occur in the future. The report also raises the issue of water depth affecting habitat. It would be helpful for these points of significance to be raised and elaborated upon at the beginning of the section.

Three studies are identified: Goldman, ADEC and USGS. It would be helpful to summarize the studies in table form within the report so that the reader can easily compare them. Then an analysis and comparison of the studies would be helpful, with the endpoint of sand volume. Is a comparison of the numbers in the different studies reflective of "apples to apples" comparison, or are there significant differences in methodology? If the studies do not answer the relevant questions directly, then please tell the reader why the studies are useful for the discussion.

p. 4-36 refers to Fig 4-50 as estimates of sand resources reported by Goldman. However, Fig 4-50 is described as locations and quantities of sand estimated by ADEC. Where is the Goldman figure?

p. 4-37, 1st parag, 4th line. Sediment substituted for "sentiment".

p. 4-37, last sentence, 2nd parag. What explains the difference in the sand reserve estimate between the Goldman study and the ADEC study? Are there methodological differences? Or, is it reasonable to believe that there was three times more sand in the same area (Pt. Knox shoal) in 2000 than in the 1955 – 1967 period? Also, please make the same analysis for Presidio shoal. What explains the similarity of sand volume estimates of the two studies? Is the comparison of the study conclusions one of "apples to apples"?

Figure 4-59a. The color-coding chart is omitted from this figure. It would be helpful to include the sediment thickness (meters) color-coding chart that is shown in Fig 4-59b. This reader can distinguish four colors in Fig. 4-59b: blue, purple, light green, green. There are 10 color codes. Is it possible to obtain or create a map in which different colors can be distinguished from each other?

p. 4-38, 1st & 2nd parag. Is "sediment thickness" the same as sand thickness? If not, what would be the cubic yardage of *mineable and marketable sand* within the various lease boundaries identified in Table 4-7? If sediment thickness does not equate with sand thickness, what is the significance of sediment thickness to the purpose of the report?

p. 4-38, 2nd parag. Table 4-8. The problem with this method is that if silt and clay exceed 10%, then under the report's definition of sand the areas with 18% silt and clay (greater than 10% silt and clay) would be *entirely* omitted from the calculation. Therefore, the sand estimates may be significantly overstated.

Fig 4-57 and 4-57. For the most part, the print is too fine and faint in order to be read. Figures with greater clarity would be helpful. There are two descriptions: (1) "sediment thickness" and (2) "Isopatch (Thickness) of Sand" on the same page. If sediment is actually sand under the definition of the report, please describe it as such. Why the confusion between ADEC and the author's categorization of sand? Does ADEC have a different definition of sand than the author? If so, please clarify on the figure and in the text.

Fig. 4-59b. The boundaries of the sand leases overlay upland areas on Angel Island and Alcatraz. Is it possible to provide a diagram that is more accurate?

p. 4-38, last paragraph, 2nd sentence. It would be helpful for the reader to include this information (the significance of depletion) at the beginning of the section. (See previous comments). How great of a change in water depth would there need to be in order to change the habitat? Given a change of habitat from shallower to deeper water, would that provide greater or less biotic diversity? The BCDC Subtidal Policy Two states that deep water with sandy shoals is rare. Would this depletion cause there to be more deep water with sandy shoals? With more deep-water shoals, would that be a favorable environmental outcome?

4.4.3. Hydrology of Central Bay

p-4-45, 2nd paragraph. Is the sand at Ocean Beach naturally replenished? If so, do we know the sources?

6.0. Physical Changes in Environment Relating to Sand Mining – San Francisco Bay and Delta Sediment Characteristics

p. 6-1, 2nd paragraph. The assertion is made that the natural filling of the Bay estuary is inevitable, given sea levels at or near present levels. Does that outcome take into account human influence? How does that outcome jibe with the recent history in which sediment volume has been declining in the estuary due to dams, dredging and mining?

Given the most recent science on global warming, is it reasonable to presume that sea levels are in fact rising? What impact would that have on the sedimentary levels of the Bay?

6.1. Areas of Sediment/Sand accretions and Depletions on a Regional and Local Scale

From the 1950s to present day, how much accretion/depletion has there been in the Bay estuary? How much has there been in Central Bay and in Suisun Bay?

6.1.1. Historic Changes in Bay-Delta Bathymetry and Sediment Process

p. 6-2, 3rd paragraph. Are the "unvegetated soils" primarily fallow agricultural lands? What are some of the other significant sources of "unvegetated soils"?

p. 6-3, 4th paragraph. A map showing the location of the Southampton Shoal and the San Bruno Shoal would be helpful.

6.1.2. Anthropogenic Factors Affecting Bay-Delta Sediment Dynamics (Gold Mining, Reservoir Impoundments).

p. 6-4, last paragraph. Can the trapping of sand behind dams continue indefinitely? Is it possible for sediment behind a dam to be released into the system (other than the dam breaking, of course)?

p. 6-5, last paragraph. The Army Corps should be able to provide excellent information on volumes of sediment dredged over the last 30 years or so. Contact David Dwinnel at (415) 977-8471. Also, the policy of the Dredged Material Management Office is to encourage taking sediment out of the Bay estuary, depositing the material at the Deep Ocean Disposal site or upland. Both the DMMO objective and the actual trend of dredged material deposition should be noted in the report.

p. 6-5, 2nd paragraph and p. 6-8, 3rd paragraph. At the mining locations themselves, the deepening from mining ☒ slowing of currents ☒ increased deposition of sand ☒ filling in of the mined depressions. In general, sand mining ☒ increase tidal volume ☒ increase in sediment volume. That said, please explain the statement: "To the extent that sand removal acts to slow the reduction of the tidal prism volume, it would help maintain existing conditions relative to changes of the tidal jet transport mechanisms."
First, what is the time frame the author is using? Is the time frame the last couple of decades (?) in which sediment decreased in the system, or the past 150 years in which sediment has been increasing? If one utilizes the recent time period in which

there has been a net depletion of sediment in the system, would the sand mining serve to increase the amount of sediment coming into Central Bay from Ocean Beach and northern littoral sources? Conversely, what is the scenario over the longer term if an increase in sediment is expected in the Bay estuary? Is there some way to put in perspective the degree to which mining 1.3 million cubic yards of material can affect the tidal prism? At first blush, it appears less than minimal in its impact.

6.3.2. Local Scale.

p. 6-11, 3rd paragraph. January 1999 through December 2002 is a *four*-year period. Given a net depletion of 2.6 million cubic yards during this period, that is an average net depletion of 650,000 cubic yards per year. The total estimated replenishment of sand estimated for the four years is: 4 yrs * 350,000 cy/yr = 1,400,000 cy. So, -2,600,000 cy (net depletion) + 1,4000,000 cy replenishment = -1,200,000 cy (net mining) over the four year period. That represents an average of 300,000 cy per year of net mining.

6.3.6. Potential Physical Impacts of Sand Mining Activity on Shallow-Water and Wetland Habitat Restoration

p. 6-13, 4th paragraph. How much of the fine material is dredged inadvertently? How much of the finer material is dredged as part of maintenance of offloading facilities onshore?

6.4.1. Changes in Physical Environmental Resulting from Current Mining Activity, By Area.

p. 6-14, 4th paragraph. Again, there are four years from the beginning of 1999 to the end of 2002.

7.9.3. Benthic Disturbance and Recovery from Sand Mining Activities.

p. 7-72. Moving pothole formula. I'm not sure why you are dividing distanced traveled by the radius. Could you please explain?

p. 7-73, Calculation. Is there some reason that the divisor being utilized is total water surface area? Would it be more meaningful to divide the area disturbed by specific habitat areas so that the affect of benthic disturbance could be viewed for relevant habitat types? See Figures 7-53 through 7-62. If the habitat areas in which mining occurred were chosen as the divisors, would that be useful?

p. 7-74, 1st paragraph. On p. 2-6, 3rd paragraph, it is noted that the large grain size aggregate is discharged overboard in the mining process. The report also notes that in many cases mining done repeatedly at the same location. If that is the case, is there a build up of the larger grain size sediment on the substrate surface? If benthic community composition is affected by "the interactions between particle mobility at the sediment water interface," then why wouldn't that particle mobility be affected by the size of the particles? And if particle mobility is affected by particle size, would the mining of particles of a certain size and the exclusion of other sizes affect the benthic community composition?

7.9.4. Summary.

p. 7-75, 1st paragraph. Given that sometimes mining at the same area occurs several times a month, how would that affect recolonization of benthic organisms that have the shortest colonizing period (one month)? Assuming for discussion purposes that certain areas never recolonize, is it less environmentally deleterious to the benthic community to have "X" number of mining episodes concentrated in a small defined area over a given period of time than it is to have the same number of mining episodes spread over a much larger area?

p. 7-74, Summary. Would the number of episodes in a given time period (rate of mining episodes) qualify as a factor affecting the recovery of benthic organisms?

8.1. Sediment Dynamics

p. 8-3, 2nd paragraph. The report states: "However, the fact that, to date, sand continues to deposit within the navigational channels of Suisun Bay, Middle Ground Shoal, Carquinez Strait, and further downstream within Central Bay suggests that the source of sand and transport mechanisms are at a level exceeding the rate of sand harvest." The fact that sand continues to be deposited suggests that upstream sand for Suisun Bay, Middle Ground Shoal, and the Carquinez Strait have not been depleted. However, that fact does not suggest that the "source of sand and transport mechanisms are at a level exceeding the rate of sand harvest." Page 4-27, last paragraph, states there has been a net erosion in Suisun Bay from 1867 – 1990. The Central Bay, on the other hand, has had a net accretion from 1955 – 1990 (p 4-25). More recently, Carquinez, Suisun Bay and Western Delta show a net accretion (Table 4-5, March '99 – January '03), while Central Bay shows a net depletion (Table 4-4, October '96 – January '03). To be clear, these facts should be stated and the conclusion should follow from these facts. If there is an emphasis put on the accretion/erosion statistics of the past few years, as opposed to the last several decades, an explanation should follow concerning the rationale behind choosing one timeframe over another.

9.2.1. Quality Assurance – Critical Review of Survey.

More specificity is needed in the discussion regarding the comparability of surveys. Can adjustments be made to the existing surveys to make them comparable, or are all the surveys done to date under a cloud of uncertainty because of "modified survey methods and protocols"? Are there any surveys that are directly comparable? If so, which ones? Is it currently known what data has been deleted from the historical reports? If so, what data has been lost? If the information is available, can the current Hanson team determine data that is comparable? With respect to historical data, why is it that the Hanson team is unable to do an analysis that a "review team" could do? In other words, why can't the review be a part of this report?

9.2.3. Modification to the Bathymetric Survey Protocol and Sampling Design.

Which surveys have transects 100 feet apart? Which surveys have transects five hundred feet apart? What other transect intervals are there and to what leases do they correspond?

Page 9-6, last paragraph. Other than the control area at the cable crossing, what specific sampling design and/or analysis changes are you proposing?

Page 9-7, 2nd paragraph. The Section cited, 4.2.7, doesn't exist. There are two 4.2.6 sections, so the second one probably needs to be renamed.

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March 14, 2004

Review and Comments on:

DRAFT SAND MINING IMPACTS ASSESSMENT AND EVALUATION REPORT PREPARED BY: HANSON ENVIRONMENTAL INC., DECEMBER 2003

Executive Summary and Introduction Sections

The depth that mining typically occurs is described as 30-90 feet deep in Central Bay and 15-45 feet deep in other upstream areas. It would be helpful to have a more complete description of the range of depth that mining has, or can, occur along with the full capability of the dredge equipment so that we can better understand any potential risks associated with mining in a particular area. From the descriptions further on in Section 2, the operating depths are constrained by the barge depth. However, the drafts used to estimate the depth constraint are loaded barges. Basically, describe the "worst case" scenarios in these two geographic areas. For instance, an operation could start on a shallow shoal and move deeper as the barge fills.

In several instances throughout the report, I felt that the information, and associated analysis, that was provided was incomplete and tended to push the reader toward a premature and/or uninformed conclusion.

Section 2.0 - Sand Mining Activity (Environmental Baseline Conditions)

p. 2-27: Paragraph 3 discusses Table 2-20 and how suspended sediment concentrations decrease at 1000 feet behind the barge. Table 2-20 does not show this data.

p. 2-55: The MEC 1990 plume study was conducted at the Point Knox Shoal. How would the results differ at other sites within the Bay? Overall, I think there could have been more speculative discussion on this subject using known data of currents and tides.

p. 2-58&2-59: The benthic grab samples show high percent silt at sample site E. Can this be accounted for and where is this site in relation to mining activities and lease areas.

p. 2-29&2-76: The plume evaluation considered a maximum time of exposure ranging from 6-9.5 hours, yet some of the operations lasted longer than 11 hours. When you consider the plume duration as well, then the total exposure is almost 15 hours. The reasons for using 6-9.5 hours may have been discussed in our meetings, but it should be explained better in this report, and there should be some discussion of the effects from this "worst case" scenario.

p. 2-77: It would be helpful to see the volumes of sand mined by lease area, or at least by shoal or a smaller scale than shown.

p. 2-78 In Table 2-9, the total volumes for 2001 &2002 do not equal the sum of the 2-80: preceding columns. Why the discrepancy?

In Tables 2-10 through 2-13, are the number of events shown a sum of all activities for all parties?

p. 2-81: In Table 2-16, Site E results showed a much lower percentage of sand. As brought up previously, can this be accounted for or are there pockets of less coarse sediments within the shoal areas?

In Table 2-17, it appears that in several instances the plume has lower concentrations of suspended sediments than the receiving waters. Does this indicate unreliable data due to sampling? Can this be otherwise accounted for?

p. 2-82: Table 2-18 is confusing. I do not understand what the values mean. This is an example of where more information in the title would be helpful to understand the purpose of table or figure.

p. 2-83: Table 2-19 is also confusing. It appears that the ambient conditions are quite variable. It is also difficult for me to tell what numbers I should be comparing and why. More text guidance accompanying the table would be helpful.

Table 2-20 seems to be incomplete (see p. 2-27 comment), or I may just not understand its purpose.

Figures and Tables Overall
Several of the figures and tables are confusing. It would be helpful to have more information in some of the titles explaining the importance of what we are looking at, and why. Keying them back to the appropriate text page # would also be helpful.

Section 4 - Physical and Water Quality Characteristics of the Bay-Delta Estuary

p. 4-2: ed. "dynamics of sentiment" in the first line. (Does this mean that we are taking this process too personally?)

p. 4-20: **The 4th paragraph** states that "the pocks have not been shown in historic bathymetric plots". Would historical charts actually be able to show these, given the technology and methodology used? If they could, what is meant by this statement? A statement might be made that the formation of these "pock marks" is not understood.

p. 4-29: Paragraph 2 appears to be incorrect based on my view of Figures 4-24 to 4-38. I may be confused about what the figures are showing, but I don't see the pattern that is described in the text.

The 3rd paragraph describes survey results and volume estimates of depletion/accretion within each of the lease areas. I have not been able to get any of the numbers to add to what is reported in the text, or on Table 4-4 for that matter. It appears that the estimate in the text shows a depletion of 2.6 mcy during the period from January 1999 to July 2002 is an order of magnitude off. Table 4-4 shows it to be ~26 mcy.

p. 4-30: The bathymetric surveys showed that changes in depth varied greatly at the Central Bay sites, from -18 feet to +4 feet. Yet this is not even mentioned in the summary, nor is the fact that overall there was a net depletion of 26 mcy from January 1999 to July 2002.

I do not believe that the summary paragraph (?) fairly summarized the section.

p. 4-32: In the second paragraph, Gilbert (1917) is quoted "Nothing coarser than fine sand gets past Pinole shoal. The coarse sand and fine gravel is reduced by attrition before it reaches San Pablo Bay." If this is true what is the cause of attrition, and does it still occur today? Does it really just break down to fine sand and silt by the time it gets there? Is there any data to support that conclusion?

p. 4-33: Paragraph 2 states that there does not appear to be significant net erosion taking place in Central Bay. See discussion of p. 4-29 and Table 4-4.

p. 4-36 to 38: The calculations seem to be focused on the volume of sand down to 90 feet and not the total amount of sand. For discussion of budgets and overall impact a relative estimate volume of total sand should be included and discussed.

Comment note: There has been no speculative discussion regarding how the current mining activities might be affecting bathymetry in San Francisco Bay-Delta. There are only statements that observations seem to show little or no changes occurring since sand mining started. I believe that to better understand what potential impacts may occur from new activities, it is imperative to at least try to understand what current impacts may be occurring. If there has no discernible changes caused by current sand mining, then what changes would be evident had no mining occurred? Would there be an overall net accretion, or would sand merely be flushed out of the system?

p. 4-40: Section 4.4.1, first paragraph states that approximately 90% of the freshwater inflow to SF Bay comes from the Delta. How was this determined? By drainage area, measured flows or ...??? Is this estimate current and what has been the history of flows since the onset of sand mining? There are several proposals to reduce the amount of inflow to the Bay, but I did not see the potential effects of these reductions discussed.

p. 4-45: Paragraph 2 states that sand and gravel replenishment comes from outside the Golden Gate and Angel Island. Is there any recruitment at all from the Delta or other upstream sources? If none, then where does that sand go (attrition or right on out of the bay?). Also, what are these estimates based on?

p. 4-61: Paragraph 4. "Limited info on sand budget...". Again, I ask if there has been any evaluation of what would the status be if no sand mining had occurred? Can this be modeled using existing information?

Fig. 4-50: It is difficult to differentiate between sand and gravel (both yellow on my copy).

Fig. 4-59a &b: I am assuming that the legend of sediment thickness is the same for both figures. Figure 4-59a is not visible. Can these figures be combined into one?

Section 5.0 - Aquatic Habitats and Community

p. 5-3: There is no discussion of *Ruppia Maritima,* or widgeon grass, which occurs in similar zones as that of eelgrass, but in the lower salinity waters like Suisun Bay. This is an important habitat feature for many fish and invertebrates.

p. 5-4: The discussion of eelgrass mentions how the extent of eelgrass beds has increased, yet is still less by percentage than other large estuaries and bays along the Pacific Coast. It should be noted that the density is decreased and morphologies of the beds is different when compared to these other bays and estuaries.

p. 5-55: <u>Table 5-21</u>. I believe that the "Presence at Station 213" column is misleading. It seems to me that it implies that the species are not at the station. It actually means that they were not caught at that station, which is different. This can be a gear issue or methodology issue, and not indicative of presence/absence. Some species can quite effectively elude the sampling gear and methods used by CDFG. It would be better to use different terminology like "observed/none observed" or "caught/none caught". There is also historic data for certain species that is applicable for our evaluation of impacts to Essential Fish Habitat.

Also, are the species listed as "not present" at Station 213 present at other nearby CDFG stations?

Section 6.0 - Physical Changes in Environment Relating to Sand Mining – San Francisco Bay and Delta Sediment Characteristics

p. 6-3: <u>Central Bay</u>. How was the line drawn between East and West Central Bay? Also, it is stated that section 4 describes a net accretion in historic time, yet from my previous observations, there appears to be a significant depletion in recent years. If I understand this correctly, then historically there was accretion that, in recent years, has changed so that it is significantly depleting. I think that this type of discussion should be more clearly broken down, so that it is less confusing and discusses this more thoroughly.

p. 6-4: <u>San Francisco Bar</u>. There is reference to a net accretion for this area, but I could not find this in the data.

The shrinking radius of the Bar could be due to less water outflow volume that is more tightly regulated. It could also be due to more fill and levees that have reduced the tidal prism.

p. 6-4: <u>6.1.2</u> - Natural sedimentation would have occurred, but might have been flushed out during significant outflow events (e.g., storm events, snow melts, etc.).

p. 6-5: What is the magnitude of volumes of oyster shell are mined from SF Bay?

It is stated (from DiSalvo 1977) that an annual average of 10.3 mcy of mainly fine-grained sediment is dredged in the Bay-Delta estuary, of which most is disposed back into the estuary. Within the purview of the DMMO, the interagency group that regulates dredging and disposal in San Francisco Bay, the annual dredging in recent years is probably about half that amount, or ~5.0 mcy, with less than 3 mcy going back into the Bay at designated disposal sites. This is a net depletion of about 2 mcy annually. Is the information cited out-dated or is there a significant amount of dredging activity within the Bay-Delta estuary that is outside of the DMMO's jurisdiction? Table 8-1 on page 8-16 of this report has specific information on in-Bay disposal activities over the last 12 years, and reports an average annual amount of ~2.4 mcy being disposed of in-Bay disposal sites (29 mcy over 12 years).

Related Overall Comment:
There is an increasing amount of upland disposal being conducted, which may increase even more significantly with the Hamilton Restoration Project coming online. This will result in an even greater net depletion due to dredging activities. There are also several other wetlands restoration projects under way or planned for the near future, including the omnipotent South Bay Salt Pond Restoration Project. These projects will need a tremendous amount of fill sediments to achieve the appropriate elevations for restoration. Some of them will achieve this by allowing natural sedimentation to occur, others will transfer the material directly or a combination of the two. Regardless of how these projects achieve the necessary elevations,

these activities will be a significant sediment sink for possibly the next few decades.

p. 6-6: Suisun Bay. It is interpreted that the significant sand transport occurs during the occasional large flood, high flow events. How was this interpretation made? Also, what is the relative transport of sand during other flow regimes?

p. 6-9: 1st paragraph. Based on the discussion in this paragraph, one could conclude that the mining of sand in Suisun Bay contributes to the deposition of fine-grained sediments in upper San Pablo Bay. This sediment is already fine-grained and gets resuspended every tidal cycle, resulting in unsuitable conditions for eelgrass, oysters, and possibly other organisms. I might infer from this that sand mining activities could be contributing to this state of San Pablo Bay.

p. 6-10: Section 6.3, paragraph 2, last sentence. The authors conclude that the ongoing deposition of sand in the Marina and the open water to the north indicates that sand mining does not have any detrimental effects. I don't see how this conclusion could be made based on this information. I do not believe that the system is as simple as "if we see deposition in one place then our removal in another area must not be having any impact". There are many dynamics that need to be considered and measured before we can conclude anything. Another perspective might be: If sand mining activities ceased in Central SF Bay, thus changing the shape and depth of the sand shoals, might then change the hydrodynamics so that sand deposition would not occur at the Marina, but deposit elsewhere replenishing a beach.

Section 6.3.1. I disagree with this first paragraph. The fact that none of the studies have identified sand mining as a causative factor in changes to deposition and erosion of shallow areas does not justify concluding that sand mining impacts are negligible. It merely means that either they have not either observed any impacts, or possibly even considered sand mining as a causative factor. I would consider this a gap in knowledge, rather than a basis for making conclusions.

p. 6-12: Top of page, last line. Statement "No long-term patterns of effect from sand mining are obvious". This statement is misleading since we don't have a baseline knowledge of what conditions were "pre-sand mining" for which to judge any long-term patterns of effect.

Section 6.3.4. The 3rd sentence states that contribution of sand mining to a net depletion in Suisun Bay and San Pablo Bay is probably negligible. On what data or information is this judgment made?

p. 6-12&13: Section 6.3.6 Paragraphs 2&3. It is concluded that because the potential restoration areas are upstream of sand mining activities, that there is no evidence to suggest that sand mining would result in changes to accretion or depletion of sediments within restoration sites. I have two issues with this statement: 1) There are many restoration activities downstream" of sand mining activities (see next paragraph). Also, in these areas, the water flows in both directions; 2) Removal of substrate downstream can result in increased erosion upstream in some situations. I believe that this is another instance where a statement is made that is misleading and does not provide a complete evaluation of potential impacts.

p. 6-13&14: Section 6.4. I was not aware that a long-term natural trend of sedimentation filling the Bay-Delta estuary was identified and documented. In fact, it seems that the opposite is true. According to reports by the USGS, there appears to be erosion occurring at least in Suisun and San Pablo Bays. This report itself has also identified a net depletion of sediment in the lease areas based on ongoing bathymetric surveys.

Therefore, I do not understand how the sand mining activities are slowing and offsetting the natural filling processes, if there are none. In fact, if there is a net depletion or erosion occurring then sand mining activities could actually be exacerbating the erosional processes.

Section 7.0 - Assessment of Potential Direct and Indirect Impacts of Sand Mining on Aquatic Species and Their Habitat

p. 7-6: Section 7.3, paragraph 2. Impacts of sand mining on aquatic plants is **not** limited to areas in which the plants occur. There are potential indirect impacts due to increased erosion in shallow areas caused by the removal of substrate in deeper adjacent, or upstream areas.

Bottom. I do not agree that no significant direct or indirect impacts have been identified as a result from sand mining. My previous comment just identified a potential indirect impact.

p. 7-8: Top paragraph. As mentioned previously the use of 9.5 hours as a maximum duration may not be indicative of some mining operations. Although, I think we agreed on it as a group, however it might be noted that the actual maximum duration could be as much as 15 hours (if my previous calculation was correct).

Figs. 7-11 through 7-26: Change the "shaded" areas so that they are transparent. Any data points that are within the "shaded" areas are currently blocked out and cannot be seen.

p. 7-44: Bottom, last sentence. Available evidence suggests that entrainment is not a significant problem. How was this conclusion arrived at? This conclusion is somewhat arbitrary. The previous two sentences discuss the difficulty with trying to estimate the effects of entrainment, and determine any population effects with any accuracy or confidence. Also, in a previous paragraph at the top of this page, it states that Larson and Moehl (1990) concluded that anadromous fish are unlikely to be entrained in significant numbers. They apparently observed some anadromous fish being entrained albeit at low numbers. However, it should be understood that for ESA-listed species, any number of organisms being entrained is significant. In the case of some of the areas in Suisun Bay the area may be constricted enough so that there could be a greater likelihood of entrainment of outmigrating juvenile salmonids.

Tables 7-32 and 7-33. What is the difference between these two tables? The dataare different but the titles and column headings are the same.

p. 7-47: Top. Estimates of crab loss due to sand mining entrainment is ~0.7% of the commercial landing. This is not expected to be significant, but how important is it? And, until we see Section 8, this loss could be significant when considered cumulatively with other types of losses and entrainment.

Shrimp entrainment is expected to be 15-20% of commercial landings?!? I would consider that to be significant. I think that this statistic warrants more discussion than just reporting it. It seems that calls of no significance are made quickly elsewhere and, in my estimation, prematurely, yet there is no significance call regarding this loss estimate. This is an important prey species for many fish species, and an important component of the food web.

p. 7-76: Summary. It states that bathymetric contour comparison provided no evidence to suggest that sand mining was resulting in substantial changes to the quality or availability of habitat. I do not understand how this conclusion was reached when the information in Tables 7-69 to 7-72 show that there is decreases in the amount of certain depth ranges that is important for a number of aquatic species. In Table 7-69, Central SF Bay, there is a loss of 1.1% of the habitat between the depths of 12-18 feet and losses of greater than 1% for habitat at depths greater than 30 feet. Both of these habitat depth ranges are important for out migrating salmonids or halibut and other groundfish that utilize the Central Bay. In Tables 7-70 through 7-72, there are losses in each area ranging from 2.5% to 11.8% of shallow water habitats (less than 12 feet deep). I think this is worthy of more analysis before it is dismissed as "no evidence".

p. 7-77: There is no Essential Fish Habitat designated for Pacific herring. They are not managed by Pacific Fishery Management Council under any of the Fishery Management Plans, which designate EFH for managed species.

There is designated critical habitat for coho salmon in Central SF Bay.

Last paragraph with Fig. 7-53. This discussion of fish habitat usage does not include any discussion of which life stages of which species are shown in the figure. Also, which data are used to mark the areas? This discussion and the associated figures should be expanded so that it is more explicit. As it is, it is interesting, but the reader suspects that there is more information behind this. I think that this information could be more usefully presented.

p. 7-78: Shiner Perch. Shiner perch are shown on the map in Figure 7-54 to utilize the same areas where sand mining occurs, yet the impacts are dismissed due to the fact that shiner perch don't utilize areas deeper than 30 feet. This is contradictory.

Statement that "since shiner perch are live bearers, no adverse effects are expected on reproductive success" is incomplete. What about any adverse impacts during fertilization processes? Also, there really is no discussion about the sensitivity of the live-born young. It is stated in this section that they are sensitive to the elevated concentrations of suspended sediments associated with sand mining activities.

Basically, the whole shiner perch section is fragmented, unclear and contradictory.

Rockfish and Lingcod. The description of habitat preference is a generalization and is true for adults mostly, and of only some species. Juveniles of many rockfish species and lingcod can be found in a variety of habitats including eelgrass, shellfish beds, and even around certain types of shoals.

Lingcod juveniles will settle on the bottom after being pelagic for ~ 3 months. They will settle on nearshore sand and mud bottoms to depths of 333 feet [2].

The second paragraph on rockfish is incomplete and inconclusive and incorrect, since many juvenile rockfish and lingcod are pelagic for a short period of their life and then as they settle they possibly could utilize the sandy bottom areas where sand mining occurs.

Basically, the section on rockfish and lingcod is incomplete. It generalizes about these species and seems to only consider adult life stages. There are a number of rockfish species that are documented in the Central Bay habitats, some of which have differing life histories, and utilize various habitats differently. To my knowledge (from various references and personal communications), there is evidence that the following species can be found in addition to lingcod within the Central SF Bay area: black rockfish, blue rockfish, brown rockfish, olive rockfish, black and yellow rockfish, yellowtail rockfish, cabezon, boccacio and kelp greenling.

p. 7-81: Striped bass. Please identify the source of information for statements like "areas identified as primary adult striped bass foraging habitat". I am assuming this information came from the party boat captains, but it would be helpful to document the source of the information.

p. 7-81: 2nd Paragraph. I think this paragraph is very incomplete, and I don't follow the logic during the conclusion leap. I think that the types of impacts have been pretty well identified in previous chapters, and many of the impacts have a range that goes beyond the footprint of the sand mining operations. Therefore I disagree with the statement that sand mining "is not expected to have a direct adverse effect on habitat conditions for striped bass".

p. 7-82: Northern anchovy. Is the statement about the swimming ability and the expected capability to avoid entrainment documented somewhere? I would like to see more background information to confirm this statement.

p. 7-85: Bay shrimp. The 3rd paragraph discusses how shrimp are vulnerable to entrainment during dredging, and are in the area where sand mining occurs. The next sentence attempts to minimize the potential entrainment impacts to shrimp by saying that they have a swimming ability that would allow escape. It is important to note that while bay shrimp may have the ability to escape, they still need to have incentive to escape. Also, if dredging equipment will entrain bay shrimp, then I would assume that sand mining equipment would entrain these shrimp. While the dredge head is buried, using the pothole method, this could actually increase the vulnerability of bay shrimp to entrainment, due to its presence not being sensed by the shrimp effectively.

The 4th paragraph states that bay shrimp "do not appear to be concentrated within those areas where sand mining occurs". Is this documented somewhere, or is it speculation? If it is speculation, then what is it based on?

p. 7-86: 4th paragraph cont'd. It is stated that entrainment is "not expected to result in significant adverse impacts to the bay shrimp population". What is this conclusion based on? What would be considered a "significant adverse impact"? As there is no cumulative impact discussion, then it is quite difficult to estimate what the overall significance of the losses due to entrainment.

6th paragraph. I do not recall any previous discussions about the "depressions" caused by the sand mining operations. These should probably be discussed in section 2. How long do they persist? How large are they? Would they really last long enough to "attract" shrimp to them?

p. 7-89: Summary. The 2nd sentence attempts to minimize the potential impacts rockfish and lingcod by stating that they are not concentrated in the areas where sand mining occurs. As mentioned in my previous comments on the section that specifically discusses lingcod and rockfish, this conclusion is erroneous, based on the assumptions presented in this report.

p. 7-97 & The conclusions in the paragraphs discussing impacts to bay shrimp both state 7-98: that direct or indirect impacts to bay shrimp harvesting is not expected. However the estimates for entrainment losses are ~7.5% of the commercial harvest. I think this should be noted, and not just dismissed. Without looking at all of the impacts to this fishery, it is difficult to really know what the "significance" level is.

General Comment:
Quite often in the report, the discussion in this section focuses on "the majority" in many instances, and is totally silent about "the minority". There should be more discussion about the potential impacts not just dismissal of impacts based on "the majority". It may be wishful thinking, but I think that one of the most important objectives of this study is to try and identify the not-so-apparent adverse impacts and not just generalize the obvious ones and then try to dismiss them.

Section 8.0 - Cumulative Impacts

p. 8-0 Where is it?

Section 9.0 - Recommendations for Additional Investigations

Forthcoming- still in review.

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September 15, 2004

Mr. Chuck Hanson
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Review of Draft Assessment and Evaluation of the Effects of Sand Mining on Aquatic Habitat and Fishery Populations of Central San Francisco Bay and the Sacramento – San Joaquin Estuary.

Dear Mr. Hanson:

Department of Fish and Game (Department) has reviewed the *Draft Assessment and Evaluation of the Effects of Sand Mining on Aquatic Habitat and Fishery Populations of Central San Francisco Bay and the Sacramento – San Joaquin Estuary* (Assessment). The Assessment evaluates the potential for commercial sand mining activity occurring in selected areas of San Francisco Bay (Bay) to adversely impact habitat and fishery resources. We understand that the scope of the Assessment has been limited to a review and analysis of existing scientific information including peer-reviewed scientific literature, technical reports, and other sources. It is our understanding that no field investigations were conducted as part of the current study. We further understand that the marine aggregate industry is interested in expanding current levels of sand mining within the Bay by either locating new mining sites or increasing the volumes of sand that could be harvested from existing lease locations. It is anticipated that the current Assessment could be used in the environmental review which would be required prior to any expansion of sand mining activity in the Bay. The Assessment is sufficient to provide a programmatic level evaluation of sand mining associated environmental impacts and the available information regarding these impacts. Additional site specific environmental field work will be required to more adequately evaluate the impacts of sand mining in the Bay on a site specific basis.

Our comments are provided pursuant to the Department's jurisdiction over the conservation, protection, and management of fish, wildlife, native plants, and

Mr. Chuck Hanson
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habitat necessary for biologically sustainable populations of such species in California (California Fish and Game Code [FGC] section 1802, California State Constitution article 4, section 20, and 43 USC section 1311). The Department has performed our review consistent with the provisions of the California Environmental Quality Act (CEQA).

The Department has six principal concerns regarding the Assessment and future expansion of sand mining. These concerns are: (1) the lack of specific information regarding the exact impact to the sea floor and associated biological community; (2) the possible impacts to listed species from the sediment plumes; (3) the likely entrainment of both listed and non-listed marine organisms; (4) the nature of the disturbance to, and possible delays in the recover of benthic communities; (5) cumulative impacts; and (6) the lack of site specific information.

Although the Assessment describes the general nature of mining activities, further information on the depth, width, and persistence of potholes and trenches is needed to fully understand the localized and broader "Bay-wide" impacts from these operations. The Assessment notes that sand mining occurs in limited areas of the Bay, due to limitations in equipment, water depth and sediment type. The Department recommends estimating effects of sand mining over the total lease area of 13 million square yards (117 million square feet), rather than over the entire bay area of 1967 million square feet. Also, the Assessment looks at long term changes which may be attributed to sand mining. The Department suggests looking at episodic changes due to sand mining events and summing changes seen during these individual mining events to estimate the total episodic changes expected. The duration over which these changes are expected to persist should also be described.

The Department is also concerned about possible impacts associated with the sand mining discharge plume. It is known that suspended sediments can have an effect on fish larvae and macro invertebrates. The Assessment notes that "the two lowest lethal response rates, found for white perch, were either a low dose of 155 mg/l over a 48 hour period, or a higher dose of 373 mg/l over 24 hours resulting in 50 percent mortality: (LC 50). Stripped bass are noted in Table 7-9 to exhibit 50 percent mortality with a 24 hour exposure to a total suspended sediment level of 485 mg/l. The Assessment also notes that "water sampling data indicated that at less than 100 m from the dredge, total suspended sediment concentrations were 480-611 mg/l in the lower water column and 80-340 mg/l in the upper water column." We question if the Assessment is citing work conducted with white surfperch (*Phanerodon furcatus*) which could be resident in the Bay, or another fish. In either case, it appears that within 100 meters downstream of the sand dredging activity, fish are exposed to suspended sediment concentrations at or above possible LC 50's. The Assessment also

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notes that “sand mining events generally last from 3 to 5.5 hours, with a range of 1 hour to over 11 hours.” The Department believes that exposure to suspended sediment concentrations at these levels and for this duration could be sufficient to result in some level of mortality to sensitive fish species; particularly for the larval life stages of such species. Should this mortality involve a state or federally listed species then such an impact would be viewed under the requirements of CEQA as a mandatory finding of significance and would also require “take” authorization from the Department (CEQA guidelines section 15065, FGC section 2081). The Department concurs with the Assessments’ assertion that the potential for sand mining to impact state or federally listed species will be site specific and vary due to environmental factors.

The Department is also concerned about the likely entrainment of marine organisms during sand dredging operations. The Assessment cites studies that found salmon fry and smolts suffer high entrainment rates by both pipeline and hopper dredges, particularly when salmon occupied the entire water column in narrow constricted channels. It was hypothesized that a factor contributing to higher entrainment rates was the inability of salmon smolts and fry to actively avoid the suction force of hydraulic dredges. Studies estimated that 0.00004 to 0.4 percent of the total out-migration of salmon fry and smolts were entrained by hydraulic dredges. Furthermore, post entrainment mortality at the dredge discharge was found to be at or near 100 percent. A number of salmonid stocks found within the Bay are both state and federally listed. As mentioned above, any mortality to these listed species associated with sand mining activities would be considered significant under CEQA and would require authorization from the Department.

Non-listed species also are likely to be entrained by sand dredging operations. Estimates provided in the Assessment indicate that Dungeness crab and bay shrimp are entrained in large numbers. Dungeness crab, *Cancer Magister*, enter the Bay at approximately four months of age where they spend up to one year maturing before migrating back to the open ocean. Sandy bottom deep-water channels in the Bay are used for this in- and out-migration (see reference). Sand mining occurs within Dungeness crab migration corridors and likely result in entrainment of young Dungeness crabs. The Assessment utilized Department otter trawl data to estimate the numbers of crabs entrained by sand mining during the 2002-2003 year. Based upon data presented in table 7-27 of the Assessment, approximately 125,546 Dungeness crabs were estimated to be entrained during the 2002-2003 season. This entrainment number equated to an adult impact estimate of 7,304 individuals. The adult impact number was then compared to the total Dungeness crab harvest for the season as a means to determine the significance of sand mining associated entrainment impacts.

The Department does not concur with a methodology that compares Dungeness crab entrainment mortality with the commercial catch as a means of

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evaluating significance. Dungeness crabs removed by entrainment are lost to the Bay ecosystem and would, subsequently, provide little or no prey benefit to other Bay organisms or to residents of the State. A better comparison for the purposes of predicting impacts would be to estimate the crabs lost due to entrainment with an estimated total number of Dungeness crabs present within the Bay. Utilizing this revised method would indicate an overall sand mining impact to the Bay Dungeness crab population and Bay ecosystem.

The Assessment also predicts entrainment of bay shrimp, family *Crangonidae*. Based on information contained in Table 7-41, approximately 385,442 bay shrimp were estimated to have been entrained in the 2002-2003 season. As in the case of Dungeness crab, this estimated number was used to for comparison with the commercial harvest of bay shrimp and a determination of significant effects. The Assessment notes that entrainment of shrimp is equal to approximately 15 to 20 percent of the commercial catch. In this case the comparison of the estimated entrainment number with the level of commercial take of bay shrimp is relevant because the commercial fishery occurs entirely within the Bay. Entrainment mortality of bay shrimp is in addition to the losses associated with the commercial fishery. The Department believes that this level of entrainment derived mortality is significant. As noted above for Dungeness crab, bay shrimp removed from the ecosystem by entrainment provide no benefit to the ecosystem or residents of the State.

The disturbance of benthic habitat is also of concern to the Department. The Assessment notes that the areas in which sand mining occurs are the high water velocity areas of the Bay. Benthic marine organisms specifically adapted to these high energy areas may be specifically affected by sand mining. The Assessment states that "communities in sand and gravel could take 2 to 3 years to establish, depending on levels of disturbance by waves and currents." The Department is concerned with the repeated nature of sand mining occurring within a limited lease area, the amount of area affected, and the nature of the recovery of the affected area, especially in light of the fact that no specific data regarding the extent or type of disturbances which may occur during sand mining, or the benthic recovery time expected from such disturbance, are available. The Department suggests that any comparisons on benthic effects should be done between areas mined for sand and other non-mined areas of similar habitat type and include evaluations of percent sand composition, and water flow velocities.

The Department believes that the incremental effects of sand mining have the potential to contribute to cumulative impacts from a variety of other activities. These cumulative impacts could adversely affect habitat quality and availability and the population dynamics of various fish and macro invertebrate species within the San Francisco Bay-Delta Estuary. The Assessment notes in numerous places that there is a lack of information specific to mining activities occurring in the Bay. The Department supports the recommended studies

identified within the Assessment with special interest being placed on the following:

- A study to sample fish and invertebrates entrained during sand mining operations.
- A comparative study of the community structure of sandy high energy areas within the Bay.
- A pre- and post-sand mining study on the effects on sand mining on the high energy sandy bottom habitat within the lease areas. This study should identify the types of organisms impacts as well as likely recovery times from dredging impacts.
- A comparison of the impacts to fish and invertebrates within the Bay to populations within the Bay. We would recommend an analysis of how the loss in marine organisms affect the Bay ecosystem or portions thereof.

We thank you for the opportunity to review and comment on the Assessment, and look forward to assisting you in the development of further studies. As always, Department personnel are available to discuss our comments, concerns, and recommendations in greater detail. To arrange for a discussion please contact either Mr. Tom Napoli, Staff Environmental Scientist, at 562-342-7164, or Mr. George Isaac, Environmental Scientist, at 831-649-2813.

Sincerely,

Eric J. Larson,
Northern California Manager/
Bays and Estuaries Ecosystem
Coordinator, Marine Region

References:

Life History, Environment, and Mariculture Studies of the Dungeness Crab, *Cancer Magister*, With Emphasis on the Central California Fishery Resource, P. Wild and R. Tasto, California Department of Fish and Game, Fish Bulletin 172, 1983.

cc: Mary Howe, CA State Lands Commission
Steve Goldbeck, SF Bay Conservation and Development Commission
Brenda Goeden, SF Bay Conservation and Development Commission
Brian Mulvey, NOAA Fisheries
Ryan Olah, U.S. Fish and Wildlife Service
Mr. Thomas Napoli, CA Department of Fish and Game
Ms. Becky Ota, CA Department of Fish and Game
Mr. George Isaac, CA Department of Fish and Game

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ARNOLD SCHWARZENEGGER
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March 15, 2004

Mr. Earl Bouse
132 Cottage Lane
Walnut Creek, CA 94595

Dear. Mr. Bouse:

Assessment and Evaluation of the Effects of Sand Mining on Aquatic Habitat and Fishery Populations of Central San Francisco Bay and the Sacramento – San Joaquin Estuary dated December 2003

Thank you for providing the Department of Conservation's Office of Mine Reclamation (OMR) the opportunity to review the environmental documentation for the expanded sand mining operations in the Central San Francisco Bay and the Sacramento - San Joaquin Estuary. We hope that the following comments will assist you in your identification and assessment of environmental impacts associated with sand dredging operations.

- The document states that its goal is to evaluate the effects of current and future expanded sand mining activities. However, revised estimates of projected future sand mining activity are not available and not quantified in the documentation. The impact analyses presented are based on current conditions, where generally no impacts are discernable. The conclusions presented here are credible based on today's activities, however, without an idea of the magnitude of expansion of both sand mining and the cumulative effects of maintenance dredging activity future impacts cannot be adequately evaluated.

- Monitoring estuary bathymetry and substrate material must be linked to adaptive management goals, and not done simply to observe conditions. A section discussing adaptive management goals should be provided in the document. As an example, one management goal might be to avoid significant changes in the substrate that may result from dredging that would negatively affect benthic habitat. To attain the goal, susceptible areas of the estuary that could be adversely affected should be identified, and thresholds would be specified that trigger the implementation of changes in dredging activities, such as avoidance of an area, that would mitigate substrate changes. An avenue to identify additional adaptive management goals as they become apparent should also be opened.

- The document states that few aquatic organisms feed upon vascular plants (page 5-2) but fails to mention the importance of vascular plant species for non-aquatic species. Eel grass (*Zostera marina*) is important forage for Black Brandt (*Branta bernicla*) and Canada Goose (*Branta Canadensis*). Both *cattails* (*Typha sp.*) & Tules (*Scirpus sp.*) provide food for geese, other waterfowl and mammals.

1. A correction needs to be noted in section 5.1 page 5-2. The document refers to "*Other nuisance species of macroalgae,...include water hyacinth and the pondweed Elodea spp.*" Neither water hyacinth (*Eichhornia crassipes*) or *Elodea* are algae, they are vascular plants.

2. Existing data concerning exposure of biota to toxics as a result of mining is minimal. We would recommend that an assessment of environmental impacts consider a thorough examination of toxic exposures from buried sediments exposed by mining operations to biological receptors. The environmental analysis should consider the following:

- The toxicity data for the dredging plume presented is only from two locations located in the western portion of the bay (Presidio Shoal and Point Knox Shoal). Sampling plume data should be collected from all the dredging locations.

- Current toxicity sampling data is only for one receptor (bivalve larvae). Toxicological responses vary by species and life stage. Toxicological responses should be determined for biological receptors representative of various habitats and trophic levels. Both producers and consumers need to be included in the assessment. The document refers to an extensive "*body of scientific information*" regarding exposure of various species and and their lifestages to toxic contaminants but this information is not referenced or included in the text.

- Toxic endpoints should be presented that represent a complete range of possible adverse effects and not be limited simply to mortality.

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- Hazard indices constructed from each exposure pathway for each evaluated species should be presented. The indices should be additive when toxicological mechanisms of action are similar between toxic agents or the target organs are identical.

- Uncertainty factors should be used to calculate NOAEL for surrogate species when calculating a reference dose. The California Department of Toxic Substances Control recommends maximum uncertainty values of 500 when mortality is the sole end point of toxic exposure.

- Movement of toxic constituents associated with sediments redeposited in mined areas need to be considered when assigning risk. It is assumed that previously mined areas will again be mined in the future following redeposition of additional sediment. Continued mining will likely cause episodic exposure events that increase toxic exposure. Concentrations of toxic constituents will likely vary with time.

- Toxic contaminants of clays and other fines washed from the sands during processing activities should be assessed. Disposition of contaminated fines should be described.

- The Department of Toxic Substances Control DTSC/HERD should be consulted concerning evaluation of toxic exposures to benthic and pelagic organisms. This is not the purview of the Regional Water Quality Control Board.

If you have any question on these comments or require any assistance with other mine reclamation issues, please contact me at (916) 323-8565.

Sincerely,

James S. Pompy, Manager
Reclamation Unit

APPENDIX C

Summary of Sand Mining Events Recorded in March 2002 – February 2003 Mining Logs

As part of the 2002-2003 sand mining study, marine operators were requested to complete logs documenting individual mining events. Information contained on the logs included the date, start time, and end time for each mining event. These logs were used to calculate the duration of a mining event, initial and final GPS locations, the type of sand harvested (general grade), the volume of sand harvested (cy), and other relevant information. Using the GPS coordinates, each mining event was assigned to a region of the Bay-Delta estuary. In addition, the initial GPS location for each mining event was overlaid in a GIS data management system with results of bathymetry studies, which was then used to calculate the water depth reported for each individual mining event. Water depth calculations did not take into account tidal conditions or variation in water depth beyond the starting point for a mining event. Water depths were not determined for some mining events where bathymetric measurements for a specific location where not available.

Date	Mining Duration (H:MM)	GPS Starting Location	GPS Ending Location	Sand Type	Volume cy	Region	Depth of Mining (ft)
3/1/2002	3:45	37.49.6,122.26.0	37.49.6,122.26.0	Coarse	1340	Central	63
3/1/2002	4:00	37.49.840,122.26.237	37.49.743,122.25.582	Coarse	1936	Central	69
3/1/2002	2:25	37.49.177,122.26.526	37.49.192,122.26.479	Fill	2302	Central	70
3/3/2002	7:34	38 03 06, 121 59 05	38 03 06, 121 59 05	Fill	1461	Middle Ground	
3/4/2002	3:00	37.49.6,122.26.0	37.49.6,122.26.0	Coarse	1509	Central	63
3/4/2002	4:30	37.49.87,122.25.74	37.49.686,122.26.019	Coarse	2101	Central	76
3/4/2002	4:40	37.50.619,122.27.053	37.50.387,122.27.459	Coarse	2296	Central	72
3/5/2002	4:15	37.49.61,122.26.10	37.49.36,122.26.21	Coarse	2136	Central	66
3/5/2002	5:50	32.02.77,121.54.47	38.03.045,121.56.238	Blend	2308	Suisun Bay	
3/5/2002	4:25	37.50.674,122.26.780	37.50.418,122.27.233	Coarse	2242	Central	60
3/5/2002	4:20	37.50.406,122.27.083	37.50.601,122.27.115	Coarse	2319	Central	72
3/6/2002	3:10	37.49.228,122.26.497	37.49.218122.26.573	Fill	2312	Central	69
3/6/2002	4:25	37.50.091,122.27.061	37.50.540,122.27.264	Coarse	2299	Central	90
3/7/2002	8:02	38 03 06, 122 00 01	38 03 06, 121 59 06	Fill	1632	Middle Ground	
3/7/2002	3:30	37.50.669,122.26.755	37.50.642,122.26.838	Coarse	2226	Central	61
3/8/2002	2:30	38.02.8,121.54.6	38.02.8,121.54.6	Blend	1648	Suisun Bay	
3/8/2002	6:50	37.50.710,122.26.760	37.50.421,122.27.486	Coarse	2234	Central	60
3/9/2002	6:38	38 03 06, 121 59 07	38 03 06, 121 59 05	Fill	1413	Middle Ground	
3/11/2002	2:15	38.02.8,122.05.6	38.02.8,122.05.6	Fill	1696	Carquinez	
3/11/2002	3:00	37.49.207,122.26.528	37.49.207,122.26.528	Fill	2369	Central	71
3/12/2002	2:30	38.02.8,122.05.6	38.02.8,122.05.6	Fill	1660	Carquinez	
3/12/2002	5:46	37.49.866,122.25.986	37.49.304,122.26.350	Coarse	1943	Central	69
3/13/2002	3:30	37.49.6,122.26.0	37.45.6,122.26.0	Coarse	1441	Central	
3/13/2002	5:30	37.50.006,122.27.061	37.49.870,122.26.553	Coarse	2319	Central	96
3/13/2002	3:45	37.49.874,122.26.375	37.49.815,122.26.914	Coarse	2332	Central	82
3/14/2002	7:53	38 03 07, 122 00 04	38 03 06, 122 01 09	Fill	1585	Middle Ground	
3/14/2002	3:00	38.03.552,122.58.807	38.03.379,121.57.747	Blend	1672	Middle Ground	
3/14/2002	4:16	37.49.748,122.25.847	37.49.389,122.26.268	Coarse	1808	Central	79
3/14/2002	3:30	38.02.830,121.54.469	38.02.874,121.54.612	Blend	2120	Suisun Bay	40
3/14/2002	4:20	37.49.84,122.26.45	37.49.91,122.26.54	Coarse	2281	Central	79
3/15/2002	8:04	38 03 07,122 00 03	38 03 06,122 00 01	Fill	1472	Middle Ground	
3/15/2002	4:30	37.49.770,122.25.943	37.49.346,122.26.144	Coarse	1873	Central	71
3/15/2002	3:50	37.50.158,122.27.133	37.50.08,122.27.060	Coarse	2317	Central	88
3/16/2002	4:15	37.49.826,122.25.939	37.49.324,122.26.236	Coarse	1933	Central	65

3/18/2002	3:45	37 49 168, 122 26 554	No Data	Medium/Fine	2140.71	Central	76
3/18/2002	3:25	37.50.656,122.26.784	37.50.620,122.26.987	Coarse	2307	Central	64
3/19/2002	4:10	37 49 287, 122 26 409	No Data	Medium	1991.29	Central	63
3/19/2002	3:50	37 49.232,122.26.557	37.49.158,122.26.535	Fill	2355	Central	76
3/19/2002	4:35	37.50.599,122.26.730	37.50.486,122.27.364	Coarse	2272	Central	68
3/20/2002	7:25	38 03 07, 122 00 02	38 03 07, 122 00 02	Fill	1601	Middle Ground	
3/20/2002	2:05	38 03 645, 121 59 151	No Data	Fine	1951.86	Middle Ground	42
3/20/2002	2:30	No Data	No Data	Coarse	2023	Central	
3/20/2002	4:55	37.50.456,122.27.663	37.50.405,122.27.636	Coarse	2270	Central	
3/20/2002	5:55	37.50.604,122.26.721	37.50.458,122.27.572	Coarse	2240	Central	68
3/21/2002	1:30	No Data	No Data	Coarse	2083	Central	
3/22/2002	8:10	38 03 08, 122 01 03	38 03 07, 122 01 03	Fill	1583	Middle Ground	
3/22/2002	4:20	No Data	No Data	Coarse	2034	Central	
3/22/2002	3:35	37.50.614,122.26.774	37.50.845,122.27.227	Coarse	2271	Central	64
3/22/2002	4:55	37.50.574,122.26.944	37.50.629,122.26.941	Coarse	2252	Central	69
3/24/2002	7:18	38 03 07, 121 59 09	38 03 05, 121 59 06	Fill	1490	Middle Ground	31
3/25/2002	4:30	38.02.875,121.54.320	38.02.871,121.54.329	Blend	1957	Suisun Bay	33
3/25/2002	4:00	37.50.137,122.27.026	37.50.126,122.27.144	Coarse	2334	Central	93
3/26/2002	6:50	38 03 07, 121 59 07	38 03 07, 121 59 07	Fill	1505	Middle Ground	33
3/26/2002	1:55	37 49 283, 122 26 390	No Data	Medium	2045.39	Central	63
3/26/2002	2:25	37.49.090,122.26.920	37.49.090,122.26.92	Fill	2321	Central	80
3/26/2002	2:20	37.49.137,122.26.488	37.49.137,122.26.448	Fill	2335	Central	
3/27/2002	2:00	38.02.8165,121.52.8530	38.02.8426,121.52.5682	Blend	1625	Suisun Bay	
3/27/2002	3:00	38 03 700, 121 59 170	No Data	Fine	2012.34	Middle Ground	28
3/27/2002	3:35	No Data	37.49.899,122.26.448	Coarse	2299	Central	
3/27/2002	4:20	37.50.02,122.27.15	37.50.069,122.27.146	Coarse	2308	Central	86
3/28/2002	No Data	No Data	No Data	Fill	1662	Middle Ground	
3/28/2002	4:00	37.49.822,122.26.091	37.49.300,122.26.167	Coarse	1949	Central	69
3/28/2002	5:15	37.50.072,122.27.075	37.50.16,122.26.88	Coarse	2288	Central	89
4/1/2002	6:30	38.02.7253,121.53.8524	38.02.6458,121.53.6782	Blend	1630	Suisun Bay	
4/1/2002	0:03	38 03.60, 121 59.60	38 03.60, 121 58.00	Fill	1644	Middle Ground	
4/2/2002	2:15	38.02.6277,121.54.5691	38.02.7831,121.54.5524	Blend	1539	Suisun Bay	
4/2/2002	2:30	38 30 06.63, 121 59 01.50	No Data	Fine	2074.39	Middle Ground	
4/2/2002	4:45	37.49.6,122.26.0	37.49.6,122.26.0	Coarse	2047	Central	63
4/2/2002	4:45	37.50.620,122.26.949	37.50.231,122.27.310	Coarse	2287	Central	69
4/2/2002	5:25	37.50.539,122.27.245	37.50.495,122.27.109	Coarse	2272	Central	75
4/3/2002	3:30	37.49.7623,122.26.1343	37.49.6995,122.28.8772	Coarse	1481	Central	73
4/3/2002	3:40	38.02.8,121.54.6	38.02.807,121.54.543	Blend	2112	Suisun Bay	
4/3/2002	5:30	38 03.62,121 01.70	38 03.30, 121 58.06	Fill	1303	Middle Ground	
4/3/2002	2:25	37.49.268,122.26.578	37.49.217,122.26.633	Fill	2300	Central	74
4/3/2002	3:00	37.49.276,122.26.603	37.49.261,122.26.589	Fill	2288	Central	78
4/4/2002	3:30	38.03.0331,122.05.1668	38.02.9677,122.08.9879	Fill	1629	Carquinez	
4/4/2002	3:15	37.49.6,122.26.0	37.49.6,122.26.0	Coarse	2087	Central	63
4/4/2002	2:30	37.49.193,122.26.617	37.49.198,122.26.538	Fill	2275	Central	77
4/4/2002	3:40	37.50.691,122.26.696	37.50.537,122.26.808	Coarse	2266	Central	60
4/5/2002	4:30	38.02.8977,122.05.9548	38.02.9002,122.05.9345	Fill	1617	Carquinez	
4/5/2002	3:15	37.49.6,122.26.0	37.45.6,22.26.0	Coarse	2088	Central	
4/5/2002	4:15	37.50.577,122.26.930	37.50.377,122.26.994	Coarse	2291	Central	71

4/8/2002	3:00	38.02.7873,121.54.6273	38.02.7941,121.54.5896	Blend	1578	Suisun Bay	
4/8/2002	2:00	37 49 112, 122 26 682	37 49 112, 122 26 682	Fill	2325	Central	68
4/9/2002	4:00	38.02.9711,122.05.4255	38.02.9868,122.05.3555	Fill	1646	Carquinez	
4/9/2002	5:15	37 50 431, 122 24 798	37 49 317, 122 26 112	Coarse	1986	Central	
4/9/2002	6:45	38 03.63, 121 59.78	38 03.80, 121 58.93	Fill	1295	Middle Ground	
4/9/2002	3:50	37 50 095, 122 27 152	37 50 092, 122 27 064	Coarse	2224	Central	81
4/9/2002	4:00	37 50 137, 122 27 213	37 50 066, 122 27 163	Coarse	2288	Central	93
4/10/2002	7:30	38 02 759, 121 54 634	38 02 740, 121 54 772	Blend	1950	Suisun Bay	
4/10/2002	4:25	37 49 883, 122 27 159	37 50 065, 122 27 159	Coarse	2284	Central	83
4/10/2002	2:10	37 49 058, 122 26 907	37 49 050, 122 26 882	Fill	2320	Central	77
4/11/2002	3:30	37.49.7985,122.25.8982	37.49.7721,122.25.9360	Coarse Medium	1465	Central	80
4/11/2002	3:10	38 03 688, 121 59 130	No Data	Gravel	2058.5	Middle Ground	32
4/11/2002	4:25	37 49 862, 122 26 139	37 49 289, 122 26 132	Coarse	1898	Central	74
4/11/2002	6:42	38 03.68, 121 59.28	38 04.77, 121 58.79	Fill	1354	Middle Ground	30
4/11/2002	2:00	37 49 050, 122 26 854	37 49 038, 122 26 825	Fill	2331	Central	80
4/12/2002	1:45	38.02.9002,122.06.1860	38.02.9000,122.06.1149	Fill	1682	Carquinez	
4/12/2002	4:30	37 49 801, 122 26 142	37 49 319, 122 26 125	Coarse	1886	Central	
4/12/2002	4:55	37 49 913, 122 26 276	37 49 960, 122 26 276	Coarse	2329	Central	79
4/12/2002	4:15	37 50 164, 122 27 140	37 49 908, 122 26 704	Coarse	2297	Central	86
4/13/2002	2:30	38.02.7742,121.54.6419	38.02.7669,121.54.5982	Blend	1692	Suisun Bay	
4/13/2002	6:25	38 03.71, 121 59.90	38 03.60, 121 59.31	Fill	1360	Middle Ground	
4/15/2002	3:30	37 49 6695, 122 25 7010	37 49 6554, 122 26 0077	Coarse	1522	Central	56
4/15/2002	3:12	38 02.97, 121 55.85	33 03.96, 121 55.98	Fill	1420	Suisun Bay	
4/16/2002	2:00	38 02 7810, 121 54 6721	38 02 7686, 121 54 6160	Blend	1622	Suisun Bay	
4/16/2002	4:00	37 49 656, 122 26 115	37 49 6, 122 26 1	Coarse	1980	Central	70
4/16/2002	4:00	37 50 590, 122 26 699	37 50 563, 122 26 924	Coarse	2248	Central	69
4/16/2002	4:55	37 50 531, 122 26 675	37 50 080, 122 26 935	Coarse	2262	Central	70
4/17/2002	2:00	38 02 9066, 122 06 1914	38 02 9180, 122 06 1371	Fill	1703	Carquinez	
4/17/2002	3:40	38 02 8, 121 54 6	38 02 87, 121 54 32	Blend	2221	Suisun Bay	
4/17/2002	5:21	38 03.68, 121 59.23	38 03.70, 121 59.57	Fill	1455	Middle Ground	32
4/17/2002	4:20	37 50 491, 122 26 720	37 50 246, 122 27 007	Coarse	2319	Central	73
4/17/2002	3:20	37 49 222, 122 26 533	37 49 194, 122 26 578	Fill	2257	Central	73
4/18/2002	1:30	38 02 920, 122 06 138	38 02 899, 122 06 208	Fill	1496	Carquinez	
4/18/2002	4:00	37 49 79, 122 26 17	37 49 75, 122 26 16	Coarse	1330	Central	74
4/18/2002	3:40	37 50 545, 122 26 702	37 50 532, 122 27 504	Coarse	2310	Central	71
4/18/2002	2:35	37 49 313, 122 26 688	37 49 228, 122 26 478	Fill	2290	Central	81
4/19/2002	2:00	38 02 7720, 121 54 6494	38 02 7729, 121 54 5977	Blend	1677	Suisun Bay	
4/19/2002	2:50	37 49 569, 122 26 151	37 49 720, 122 25 750	Coarse	2114	Central	63
4/19/2002	4:20	37 49 854, 122 26 299	37 49 71, 122 25 90	Coarse	1896	Central	76
4/19/2002	5:59	38 03.400, 121 57.826	38 03.123, 121 56.027	Fill	1560	Middle Ground	
4/19/2002	4:40	37 49 230, 122 26 582	37 49 195, 122 26 589	Fill	2333	Central	81
4/21/2002	7:18	38 03.400, 121 57.826	38 03.123, 121 56.027	Fill	1540	Middle Ground	
4/23/2002	1:30	38 02 850, 121 54 617	38 02 849, 121 54 614	Blend	1710	Suisun Bay	41
4/23/2002	4:15	37 49 855, 122 25 811	37 49 345, 122 26 109	Coarse	1761	Central	72
4/23/2002	4:30	37 49 781, 122 25 796	37 49 246, 122 26 240	Coarse	1967	Central	79
4/23/2002	3:54	38 03.565, 121 59.897	38 03.662, 121 59.100	Fill	1082	Middle Ground	
4/23/2002	4:20	37 50 12, 122 26 73	37 50 10, 122 27 00	Coarse	2336	Central	
4/23/2002	3:55	37 50 116, 122 27 176	37 50 050, 122 27 154	Coarse	2305	Central	91
4/24/2002	3:00	37 49 818, 122 26 106	37 49 826, 122 26 116	Coarse	1497	Central	72

4/24/2002	4:15	37 49 870, 122 25 912	37 49 263, 122 26 119	Coarse	1734	Central	70
4/24/2002	2:30	38 02 798, 121 54 305	38 02 798, 121 54 299	Blend	2222	Suisun Bay	
4/24/2002	3:55	37 50 169, 122 27 019	37 50 169, 122 27 019	Coarse	2342	Central	92
4/25/2002	5:00	37 49 835, 122 26 124	37 49 272, 122 26 192	Coarse	1892	Central	73
4/25/2002	5:53	38 03.674, 121 59.843	38 03.56, 121 59.95	Fill	1495	Middle Ground	
4/26/2002	4:15	37 49 751, 122 26 152	37 49 274, 122 26 092	Coarse	1940	Central	73
4/27/2002	3:46	38 04.68, 121 59.08	38 03.60, 121 59.74	Fill	1504	Middle Ground	
4/29/2002	5:18	38 03.60, 121 00.40	38 03.10, 12159.85	Fill	1458	Middle Ground	
4/30/2002	4:50	37 49 60, 122 26 29	37 49 71, 122 25 76	Coarse	2097	Central	69
4/30/2002	5:00	37 49 79, 122 25 84	37 49 57, 122 26 00	Coarse	1708	Central	73
5/1/2002	1:45	38 02.8, 121 54.6	38 02 8, 121 54 6	Blend	1620	Suisun Bay	
5/1/2002	5:50	38 02 800, 121 54 490	38 02 800, 121 54 440	Blend	1840	Suisun Bay	
5/1/2002	2:50	37 49 240, 122 26 696	37 49 253, 122 26 741	Fill	2305	Central	77
5/1/2002	6:18	38 03.635, 121 59.337	38 03.647, 121 59.987	Fill	1645	Middle Ground	39
5/2/2002	3:25	37 49 77, 122 25 73	37 49 54, 122 26 12	Coarse	2002	Central	81
5/2/2002	3:15	37 49 78, 122 25 70	37 49 64, 122 25 75	Coarse	1870	Central	
5/2/2002	3:40	37 50 591, 122 26 630	37 50 503, 122 26 829	Coarse	2331	Central	68
5/3/2002	3:40	37 50 163, 122 27 143	37 50 040, 122 27 162	Coarse	2319	Central	86
5/3/2002	2:40	37 49 228, 122 26 585	37 49 231, 122 26 590	Fill	2281	Central	82
5/4/2002	6:22	38 03.885, 121 56.121	38 03.654, 121 59.508	Fill	1481	Suisun Bay	
5/6/2002	4:40	37 49 89, 122 27 21	37 49 995, 122 27 121	Coarse	2307	Central	88
5/6/2002	6:44	38 03.669, 121 00.192	38 03.61, 121 39.11	Fill	1258	Middle Ground	
5/7/2002	3:30	37 49 767, 122 25 821	37 49 702, 122 29 904	Coarse	1529	Central	77
5/7/2002	4:30	37 49 725, 122 26 126	37 49 211, 122 26 120	Coarse	1811	Central	72
5/7/2002	4:15	37 49 798, 122 26 043	37 49 345, 122 26 143	Coarse	1887	Central	
5/7/2002	4:35	37 50 07, 122 27 08	37 50 141, 122 27 084	Coarse	2282	Central	88
5/7/2002	4:00	37 49 954, 122 26 168	37 49 755, 122 25 710	Coarse	2331	Central	76
5/8/2002	3:30	38 03 026, 122 05 994	38 03 026, 122 05 994	Fill	1713	Carquinez	
5/8/2002	3:10	37 49 20.55, 122 26 13.02	No Data	Medium Sand	2201.57	Central	71
5/8/2002	4:30	38 02 755, 121 54 341	38 02 762, 121 54 279	Blend	2116	Suisun Bay	
5/8/2002	4:45	37 49 908, 122 27 185	37 50 142, 122 27 100	Coarse	2275	Central	85
5/8/2002	2:15	37 49 150, 122 26 590	37 49 144, 122 26 593	Fill	2342	Central	
5/8/2002	3:52	38 03.608, 121 00.806	38 03.686, 121 59.182	Fill	1177	Middle Ground	
5/9/2002	1:45	38 02 890, 122 06 166	38 02 906, 122 06 189	Fill	1713	Carquinez	
5/9/2002	5:15	37 49 663, 122 26 120	37 49 284, 122 26 129	Coarse	1910	Central	71
5/9/2002	2:20	37 49 146, 122 26 563	37 49 151, 122 26 615	Fill	2342	Central	70
5/9/2002	2:15	37 49 26, 122 26 71	37 49 081, 122 26 765	Fill	2372	Central	79
5/10/2002	2:45	No Data	No Data	Blend	1637	Suisun Bay	
5/10/2002	5:00	37 49 841, 122 25 734	37 49 260, 122 26 342	Coarse	1915	Central	77
5/10/2002	5:00	37 49 796, 122 26 054	37 49 281, 122 26 106	Coarse	1924	Central	69
5/10/2002	3:45	37 50 179, 122 27 058	37 50 133, 122 27 072	Coarse	2337	Central	89
5/10/2002	7:38	38 03684, 121 00.492	38 03.62, 121 59.08	Fill	1483	Middle Ground	
5/12/2002	6:02	38 03.639, 121 59.916	38 03.689, 121 59.062	Fill	1450	Middle Ground	
5/13/2002	4:00	37 49 766, 122 25 588	37 49 955, 122 25 802	Coarse	1524	Central	
5/13/2002	6:10	37 50 577, 122 27 083	37 50 50, 122 27 51	Coarse	2226	Central	71
5/14/2002	4:15	37 49 797, 122 25 871	37 49 73, 122 25 76	Coarse	2225	Central	68

5/14/2002	2:50	37 49 207, 122 26 541	37 49 200, 122 26 565	Fill	2316	Central	74
5/14/2002	3:35	37 50 589, 122 26 725	37 50 590, 122 26 871	Coarse	2261	Central	69
5/14/2002	11:12	38 03.671, 122 00.499	38 03.622, 121 00.500	Fill	1503	Middle Ground	
5/15/2002	5:25	37 49 769, 122 25 815	37 49 86, 122 25 90	Coarse	2119	Central	76
5/15/2002	3:30	37 49 26, 122 26 39	37 49 332, 122 26 311	Blend	2213	Central	60
5/15/2002	2:00	37 49 294, 122 26 583	37 49 294, 122 26 583	Fill	2348	Central	73
5/15/2002	2:40	37 49 231, 122 26 547	37 49 230, 122 26 577	Fill	2265	Central	77
5/16/2002	3:00	No Data	No Data	Blend	1624	Suisun Bay	
5/16/2002	3:30	37 49 771, 122 25 846	37 49 69, 122 25 67	Coarse	1841	Central	80
5/16/2002	3:45	37 50 586, 122 26 929	37 50 553, 122 26 934	Coarse	2304	Central	72
5/16/2002	8:30	38 03.60,122 00.158	38 03.536, 121 58.592	Fill	1558	Middle Ground	
5/17/2002	2:00	38 02 884, 122 06 192	38 02 884, 122 06 192	Fill	1652	Carquinez	
5/17/2002	6:10	37 49 55, 122 26 19	37 49 723, 122 25 780	Coarse	2237	Central	65
5/18/2002	6:20	38 03.688, 121 58.949	38 03.679, 121 58.519	Fill	1133	Middle Ground	
5/20/2002	2:45	37 48 950, 122 26 433	37 48 940, 122 26 433	Fill	1494	Central	
5/20/2002	3:50	37 50 198, 122 27 068	37 50 152, 122 27 016	Coarse	2309	Central	83
5/20/2002	8:43	38 03.711, 121 00.828	38 03.65, 121 59.08	Fill	1325	Middle Ground	
5/21/2002	4:40	37 49 743, 122 26 209	37 49 310, 122 26 099	Coarse	1935	Central	75
5/21/2002	3:35	37 50 152, 122 27 108	37 50 046, 122 27 128	Coarse	2295	Central	88
5/21/2002	2:05	37 49 189, 122 26 668	37 49 188, 122 26 686	Fill	2350	Central	79
5/22/2002	5:10	37 49 778, 122 25 886	37 49 246, 122 26 235	Coarse	1968	Central	72
5/22/2002	3:40	37 50 146, 122 27 037	37 50 094, 122 27 006	Coarse	2279	Central	91
5/22/2002	2:50	37 49 161, 122 26 637	37 49 146, 122 26 671	Fill	2346	Central	
5/22/2002	5:19	38 03.606, 122 00.051	38 03.654, 121 59.099	Fill	1522	Middle Ground	
5/23/2002	3:00	37 49 044, 122 26 333	37 49 417, 122 26 122	Fill	1633	Central	
5/23/2002	6:00	37 49 767, 122 26 182	37 49 258, 122 26 134	Coarse	1893	Central	73
5/23/2002	3:55	37 50 146, 122 27 083	37 50 090, 122 27 146	Coarse	2323	Central	88
5/24/2002	5:41	38 03.704, 122 00.892	38 03.55, 121 58.62	Fill	1542	Middle Ground	
5/25/2002	4:10	38 03.619, 121 59.890	38 03.647, 121 58.831	Fill	962	Middle Ground	
5/27/2002	7:00	38 03.654, 121 59.056	38 03.606, 121 59.099	Fill	1703	Middle Ground	38
5/28/2002	3:12	37 49.759, 122 25.955	37.49.771, 122 26.113	Coarse	1541	Central	72
5/28/2002	5:05	37 49.82, 122 25.74	37 49.730, 122 25.773	Coarse	2373	Central	77
5/28/2002	4:25	38 03.685, 122 00.150	38 03.689, 121 58.380	Fill	1316	Middle Ground	
5/29/2002	2:00	38 02.919, 122 06.134	38.03.003, 12.05.966	Fill	1541	Carquinez	
5/29/2002	5:05	37 49.675, 122 26.223	37 49.67, 122 25.70	Coarse	2397	Central	71
5/29/2002	5:50	37 50.585, 122 27.114	37 50.650, 122 27.469	Coarse	2075	Central	74
5/29/2002	3:00	37 49.205, 122 26.718	37 49.185, 122 26.655	Fill	2261	Central	79
5/30/2002	5:05	37 49.696, 122 26.236	37 49.68, 122 25.67	Coarse	2235	Central	73
5/30/2002	5:15	37 49.82, 122 25.78	37 49.68, 122 25.70	Coarse	2380	Central	74
5/30/2002	6:20	37 50.537, 122 27.087	37 50.518, 122 27.118	Coarse	2255	Central	70
5/30/2002	5:03	38 03.685, 122 00.150	38 03.689, 121 58.380	Fill	1306	Middle Ground	
5/31/2002	2:45	37 48.861, 122 25.611	37 48.861, 122 25.661	Fill	1663	Central	53
5/31/2002	3:10	37 49.234, 122 26.577	37 49.201, 122 22.206	Fill	2302	Central	80
5/31/2002	3:25	37 49.344, 122 26.629	37 49.261, 122 26.589	Fill	2379	Central	79
6/1/2002	4:07	38 03.692, 121 59.582	38 03.743, 121 58.522	Fill	1254	Middle Ground	17
6/2/2002	6:12	38 03.626, 122 00.229	38 03.650, 122 00.000	Fill	1568	Middle Ground	
6/3/2002	5:15	37 50.915, 122 25.882	37 51.034, 122 25.223	Fill	1599	Central	56
6/3/2002	3:50	37 50.144, 122 26.920	37 49.981, 122 27.154	Coarse	2287	Central	

6/4/2002	4:45	37 49.809, 122 25.744	37 49.682, 122 25.791	Coarse	2150	Central	75
6/5/2002	4:45	37 49.777, 122 25.831	37 49.695, 122 25.764	Coarse	1564	Central	77
6/5/2002	5:00	37 49.862, 122 25.804	37 49.313, 122 26.253	Coarse	2213	Central	72
6/5/2002	4:45	37 49.897, 122 26.000	37 49.316, 122 26.197	Coarse	2127	Central	72
6/5/2002	9:00	37 50.894, 122 26.135	37 51.17, 122 25.70	Fill	2230	Central	
6/5/2002	2:45	37 49.121, 122 26.843	37 49.169, 122 26.874	Fill	2326	Central	80
6/5/2002	4:58	38 03.677, 121 59.754	38 03.619, 121 58.460	Fill	1339	Middle Ground	
6/6/2002	7:15	37 48.938, 122 26.778	37 49.208, 122 26.313	Blend	1816	Central	79
6/6/2002	4:00	37 50.181, 122 27.000	37 49.982, 122 27.154	Coarse	2389	Central	93
6/6/2002	2:30	37 49.183, 122 25.557	37 49.151, 122 26.531	Fill	2346	Central	
6/7/2002	4:20	37 49.834, 122 25.809	37 49.278, 122 26.312	Coarse	1889	Central	70
6/7/2002	3:52	38 03, 121 56	38 03, 121 55	Fill	1160	Suisun Bay	
6/8/2002	3:30	37 48.862, 122 25.376	37 48.804, 122 25.825	Fill	1649	Central	54
6/8/2002	4:45	37 49.773, 122 26.959	37 49.244, 122 26.340	Coarse	1880	Central	
6/8/2002	3:54	38 02.99, 121 55.92	38 02.86, 121 54.94	Fill	1529	Suisun Bay	
6/10/2002	4:00	37 51.026, 122 25.174	37 51.127, 122 25.995	Fill	1427	Central	
6/10/2002	5:25	37 49.63, 122 26.18	37 49.708, 122 25.755	Coarse	2282	Central	66
6/10/2002	6:47	38 03.00, 121 56.00	38 03.02, 121 56.38	Fill	1426	Suisun Bay	
6/10/2002	3:45	37 49 15.75, 122 26 5.32	No Data	Medium	1399	Central	70
6/11/2002	4:15	37 49.853, 122 25.770	37 49.70, 122 25.70	Coarse	2220	Central	73
6/11/2002	2:50	37 49.238, 122 26.600	37 49.192, 122 26.646	Fill	2341	Central	82
6/11/2002	4:05	38 02.923, 121 55.584	38 03.058, 121 56.212	Fill	1227	Suisun Bay	
6/11/2002	4:20	37 49 22.41, 122 26 11.10	No Data	Medium	2097	Central	
6/12/2002	3:00	37 49.800, 122 26.231	37 49.800, 122 25.956	Coarse	1447	Central	
6/12/2002	4:10	37 49.803, 122 26.204	37 49.720, 122 25.810	Coarse	2048	Central	70
6/12/2002	4:00	37 50.563, 122 26.696	37 50.631, 122 26.749	Coarse	2327	Central	70
6/12/2002	4:05	37 50.563, 122 26.777	37 50.599, 122 26.909	Blend	2361	Central	71
6/12/2002	4:05	37 42 22.75, 122 26 10.63	No Data	Medium	1996	Central	
6/13/2002	2:50	37 49.230, 122 26.535	37 49.196, 122 26.581	Blend	2292	Central	74
6/13/2002	6:00	38 03.637, 121 59.517	38 03.598, 121 59.066	Fill	1528	Middle Ground	40
6/15/2002	4:00	37 48.86, 122 25.37	37 49.266, 122 26.597	Blend	1543	Central	55
6/15/2002	3:40	No Data	No Data	Coarse	2350	Central	
6/15/2002	6:42	38 03.649, 121 59.252	38 03.610, 121 58.567	Fill	1263	Middle Ground	36
6/16/2002	4:50	38 03.688, 121 59.299	38 03.708, 121 58.708	Fill	1582	Middle Ground	30
6/17/2002	3:00	37 49.364, 122 26.448	37 49.179, 122 26.168	Blend	1691	Central	68
6/17/2002	4:20	37 49.812, 122 25.789	37 49.310, 122 26.118	Coarse	1932	Central	76
6/17/2002	3:10	37 49.153, 122 26.659	37 49.159, 122 26.534	Fill	2334	Central	
6/18/2002	4:45	37 49.839, 122 25.751	37 49.270, 122 26.318	Coarse	1954	Central	76
6/18/2002	3:30	37 50.130, 122 27.030	37 50.003, 122 27.111	Coarse	2311	Central	94
6/18/2002	7:36	38 03.612, 121 59.649	38 03.655, 121 59.068	Fill	1681	Middle Ground	
6/19/2002	2:00	38 02.097, 122 07.398	38 02.094, 122 07.413	Spoils	1539	Carquinez	
6/19/2002	3:55	37 49.297, 122 26.461	37 49.282, 122 26.359	Blend	2074	Central	70
6/19/2002	2:09	37 49.165, 122 26.545	37 49.154, 122 26.620	Fill	2353	Central	
6/19/2002	4:35	37 51.01, 122 25.80	37 50.819, 122 26.088	Coarse	2320	Central	52
6/19/2002	4:08	38 03.639, 121 59.948	38 03.619, 121 58.76	Fill	1212	Middle Ground	
6/19/2002	4:15	37 49 18.25, 122 26 9.74	No Data	Medium	1991	Central	76
6/20/2002	4:15	37 50.954, 122 25.685	37 50.905, 122 25.557	Fill	1649	Central	59
6/20/2002	5:30	37 49.840, 122 25.891	37 49.237, 122 26.224	Coarse	1959	Central	

6/20/2002	3:50	37 50.203, 122 27.113	37 50.092, 122 27.138	Coarse	2348	Central	77
6/20/2002	4:15	37 50.140, 122 27.055	37 50.128, 122 27.072	Coarse	2278	Central	90
6/21/2002	4:15	37 50.963, 122 25.569	37 50.850, 122 25.538	Fill	1633	Central	61
6/21/2002	4:15	37 49.800, 122 25.778	37 49.649, 122 26.299	Coarse	1876	Central	77
6/21/2002	4:41	No Data	No Data	Fill	1532	Suisun Bay	
6/22/2002	5:13	38 03.690, 122 00.429	38 03.693, 121 59.557	Fill	1200	Middle Ground	
6/24/2002	3:45	37 49.345, 122 26.271	37 48.979, 122 25.627	Blend	1376	Central	65
6/24/2002	6:05	37 49.65, 122 26.18	37 49.729, 122 25.858	Coarse	1970	Central	68
6/24/2002	4:20	37 49.048, 122 26.683	37 48.871, 122 26.649	Blend	2237	Central	72
6/24/2002	7:45	38 03.655, 122 00.349	38 03.583, 121 59971	Fill	1708	Middle Ground	
6/25/2002	6:50	37 49.95, 122 25.96	37 49.724, 122 25.851	Coarse	2077	Central	78
6/25/2002	5:10	37 50.670, 122 26.844	37 50.459, 122 27.157	Coarse	2357	Central	64
6/25/2002	7:08	38 03.57, 121 58.75	38 03.754, 121 00421	Fill	1535	Middle Ground	
6/26/2002	3:45	37 49.705, 122 25.764	37 49.832, 122 26.157	Coarse	1362	Central	72
6/26/2002	4:10	37 49.953, 122 26.254	37 49.710, 122 25.702	Coarse	2205	Central	82
6/26/2002	5:20	37 50.685, 122 27.312	37 50.504, 122 27.354	Coarse	2334	Central	68
6/26/2002	5:00	37 50.969, 122 25.895	37 50.818, 122 25.873	Fill	2293	Central	52
6/26/2002	5:30	37 50.430, 122 27.263	37 50.281, 122 27.248	Coarse	1875	Central	80
6/27/2002	3:50	37 49.944, 122 26.230	37 49.702, 122 25.717	Coarse	2351	Central	75
6/27/2002	5:54	38 03.691, 122 00.438	38 03.58, 121 58.81	Fill	1435	Middle Ground	
6/28/2002	3:00	37 49.892, 122 26.168	37 47.910, 122 26.052	Coarse	1334	Central	
6/28/2002	3:25	37 50.680, 122 26.644	37 50.493, 122 26.688	Coarse	2314	Central	65
6/28/2002	6:05	37 49.937, 122 25.799	37 49.838, 122 25.799	Coarse	2247	Central	79
6/28/2002	7:58	38 03.606, 122 00.456	38 03.601, 121 58.705	Fill	1255	Middle Ground	
6/29/2002	3:25	37 49.958, 122 26.263	37 49.929, 122 26.089	Coarse	1336	Central	81
6/30/2002	5:19	38 03.62, 121 59.32	38 03.498, 121 58.436	Fill	1170	Middle Ground	40
7/1/2002	1:45	38 02.796, 121 54.568	38 02.794, 121 54.55	Blend	1661	Suisun Bay	
7/1/2002	5:14	37 49.629, 122 25.809	37 49.480, 122 26.070	Coarse	2230	Central	57
7/1/2002	4:25	37 50.181, 122 27.125	37 49.892, 122 27.118	Coarse	2346	Central	81
7/1/2002	4:30	38 03.583, 122 00.142	38 03.682, 121 58.679	Fill	1381	Middle Ground	
7/2/2002	4:00	37 50.981, 122 25.56	37 50.883, 122 75.792	Fill	1680	Central	61
7/2/2002	7:00	37 49.805, 122 25.825	37 49.746, 122 25.719	Coarse	1888	Central	73
7/2/2002	3:30	37 49.158, 122 26.505	37 49.124, 122 26.571	Blend	2326	Central	
7/2/2002	2:00	37 49.000, 122 26.875	37 48.995, 122 26.873	Blend	2338	Central	78
7/3/2002	1:30	38 02.836, 121 54.465	38 02.813, 121 54.407	Blend	1687	Suisun Bay	40
7/3/2002	5:45	37 49.753, 122 26.155	37 49.280, 122 26.122	Coarse	1864	Central	73
7/3/2002	3:30	37 49.917, 122 26.795	37 49.837, 122 26.909	Coarse	2306	Central	94
7/4/2002	7:08	38 03.696, 122 00.734	38 03.639, 121 58.855	Fill	1661	Middle Ground	
7/5/2002	6:15	37 49.417, 122 26.404	37 49.248, 122 26.355	Blend	2056	Central	72
7/5/2002	5:39	38 03.667, 121 59.066	38 04.422, 121 59.247	Fill	1394	Middle Ground	37
7/7/2002	5:32	38 03.667, 122 00.802	No Data	Fill	1547	Middle Ground	
7/8/2002	3:05	37 49.800, 12 26.153	37 49.790, 122 26.219	Coarse	1538	Central	
7/8/2002	4:25	37 49.81, 122 25.77	37 49.692, 122 25.725	Coarse	2272	Central	76
7/8/2002	4:30	37.48.949, 122 26.659	37 48.851, 122 26.966	Blend	2322	Central	77
7/8/2002	5:01	38 03.644, 121 59.956	38 03.662, 121 58.677	Fill	1302	Middle Ground	
7/9/2002	2:45	38 02.852, 121 54.687	38.02.805, 121 54.568	Blend	1676	Suisun Bay	38
7/9/2002	4:40	37 49, 122 25	37 49.704, 122 25.714	Coarse	2188	Central	

7/9/2002	5:20	37 50.711, 122 26.779	37 50.365, 122 27.264	Coarse	2299	Central	59
7/10/2002	5:45	37 49.94, 122 26.20	37 49.716, 122 25.755	Coarse	2350	Central	78
7/10/2002	5:30	37 50.663, 122 27.331	37 50.548, 122 27.534	Coarse	2340	Central	70
7/10/2002	5:40	37 50.463, 22 27.528	37 50.430, 122 27.437	Coarse	2318	Central	
7/10/2002	5:11	38 03.734, 122 00.525	38 03.628, 121 59.015	Fill	1501	Middle Ground	
7/11/2002	2:40	37 51.006, 122 25.673	37 50.784, 122 25.690	Fill	1656	Central	54
7/11/2002	8:05	37 51.029, 122 25.485	37 51.093, 122 25.895	Fill	2289	Central	58
7/12/2002	2:45	37 50.853, 122 25.589	37 50.945, 122 25.760	Fill	1656	Central	77
7/12/2002	4:50	37 50.496, 122 27.356	37 50.168, 122 27.609	Coarse	2274	Central	78
7/12/2002	4:50	38 03.674, 121 59.314	38 03.605, 121 59.543	Fill	1363	Middle Ground	32
7/13/2002	4:00	37 48.823, 122 26.576	37 48.629, 122 26.669	Blend	2330	Central	76
7/13/2002	4:25	37 50.463, 122 26.709	37 50.490, 122 26.887	Coarse	2309	Central	
7/13/2002	6:06	38 03.681, 122 00.683	38 03.639, 121 59.319	Fill	1645	Middle Ground	
7/13/2002	6:20	38 03.770, 122 00.641	38 03.600, 121 59.431	Fill	1637	Middle Ground	
7/15/2002	2:40	37 49.921, 122 25.993	37 49.896, 122 25.882	Coarse	1558	Central	75
7/15/2002	4:40	37 49.949, 122 25.911	37 49.885, 122 26.173	Coarse	1964	Central	78
7/15/2002	3:25	37 50.850, 122 27.065	37 50.752, 122 27.214	Coarse	2257	Central	62
7/16/2002	2:15	38 02.834, 121 54.781	38 02.834, 121 54.593	Blend	1677	Suisun Bay	39
7/16/2002	5:40	37 49.794, 122 27.169	37 49.821, 122 26.215	Coarse	1966	Central	81
7/16/2002	2:40	37 48.931, 122 26.517	37 48.882, 122 26.672	Blend	2313	Central	81
7/16/2002	4:10	37 50.974, 122 25.376	37 50.960, 122 25.848	Fill	2288	Central	79
7/16/2002	3:26	38 03.600, 122 00.100	38 03.598, 121 59.521	Fill	1264	Middle Ground	
7/16/2002	3:55	37 49 22.7, 122 26 14.2	No Data	Medium	1884	Central	71
7/17/2002	3:15	37 50.822, 122 25.659	37 50.847, 122 25.641	Fill	1468	Central	76
7/17/2002	4:17	37 49.058, 122 27.127	37 49.075, 122 27.078	Blend	2094	Central	81
7/17/2002	6:03	37 49.912, 122 25.863	37 49.915, 122 25.991	Coarse	2002	Central	75
7/17/2002	4:10	37 50.203, 122 27.162	37 50.020, 122 27.125	Coarse	2248	Central	83
7/17/2002	4:55	37 50.88, 122 26.74	37 51.350, 122 26.876	Coarse	2275	Central	48
7/17/2002	6:54	38 03.654, 122 00.400	38 03.601, 121 59.476	Fill	1491	Middle Ground	
7/17/2002	4:15	37 49 20.5, 122 26 14.2	No Data	Medium	1929	Central	63
7/18/2002	6:18	37 49.890, 122 26.066	37 49.893, 122 26.135	Coarse	1935	Central	74
7/18/2002	3:50	37 51.83, 122 17.80	37 51.80, 121 18.30	Fill	2297	Central	
7/18/2002	5:45	37 49 21.87, 122 26 14.81	No Data	Medium	1851	Central	
7/19/2002	4:45	37 49.874, 122 26.179	37 49.839, 122 26.093	Coarse	2027	Central	74
7/19/2002	2:15	37 51.69, 122 19.75	37 51.68, 122 19.71	Coarse	2286	Central	
7/19/2002	2:35	37 49.87, 122 19.26	37 49.87, 122 19.28	Blend	2317	Central	
7/19/2002	5:13	38 03.718, 122 01.133	38 03.734, 121 58.625	Fill	1268	Middle Ground	
7/20/2002	4:00	37 51.62, 122 19.82	37 51.57, 122 19.73	Coarse	2306	Central	
7/20/2002	3:40	37 51.03, 122 19.61	37 51.47, 122 19.54	Coarse	2315	Central	
7/21/2002	5:28	38 03.616, 121 59.779	38 03.764, 121 58.618	Fill	1619	Middle Ground	
7/22/2002	4:00	37 51.042, 122 25.521	37 50.827, 122 25.592	Fill	1687	Central	58
7/22/2002	5:30	37 49.851, 122 26.025	37 49.918, 122 26.155	Coarse	2175	Central	69
7/22/2002	3:30	37 48.510, 122 26.670	37 48.631, 122 26.741	Blend	2328	Central	
7/22/2002	5:09	38 03.640, 121 59.479	No Data	Fill	1543	Middle Ground	38
7/23/2002	3:45	37 49.874, 122 26.120	37 49.837, 122 26.130	Coarse	1594	Central	72
7/23/2002	5:30	37 49.908, 122 26.338	37 49.883, 122 26.099	Coarse	2247	Central	81
7/23/2002	4:25	37 50.742, 122 27.442	37 50.697, 122 27.467	Coarse	2286	Central	64
7/24/2002	4:30	37 49.968, 122 26.083	37 47.319, 122 15.864	Coarse	2217	Central	78

7/24/2002	4:45	37 50.995, 122 25.610	37 50.950, 122 25.590	Fill	2335	Central	57
7/24/2002	4:10	37 51.064, 122 25.559	37 51.083, 122 25.647	Fill	2266	Central	55
7/24/2002	6:46	38 03.083, 122 03.700	38 03.500, 122 03.450	Fill	1707	Middle Ground	
7/25/2002	8:55	37 51.004, 122 25.489	37 50.900, 122 25.624	Fill	1546	Central	62
7/25/2002	3:45	37 51.056, 122 27.312	37 50.731, 122 27.332	Coarse	2335	Central	57
7/25/2002	3:25	38 03.653, 121 59.299	38 03.781, 121 58.593	Fill	1349	Middle Ground	37
7/26/2002	3:15	37 50.941, 122 25.573	37 50.893, 122 25.745	Fill	1682	Central	65
7/26/2002	8:10	37 51.004, 122 25.489	37 30.900, 122 25.624	Coarse	2051	Central	62
7/26/2002	5:45	37 49.859, 122 26.031	37 49.896, 122 26.606	Coarse	2338	Central	68
7/26/2002	4:45	37 49.935, 122 26.631	37 50.070, 122 26.910	Coarse	2344	Central	87
7/27/2002	3:55	38 03.625, 122 00.517	38 03.600, 121 59.400	Fill	1381	Middle Ground	
7/28/2002	3:15	38 03.747, 122 00.374	38 03.707, 121 58.230	Fill	1355	Middle Ground	
7/29/2002	1:45	38 02.855, 121 54.641	38 02.897, 121 54.521	Blend	1648	Suisun Bay	39
7/30/2002	3:00	37 49.889, 122 26.077	37 49.870, 122 26.148	Coarse	1577	Central	72
7/30/2002	5:05	37 49.795, 122 26.102	37 49.834, 122 26.167	Coarse	1953	Central	71
7/30/2002	4:50	37 49 58, 122 26 01	37 49.831, 122 26.179	Coarse	1714	Central	62
7/30/2002	2:30	37 50.962, 122 27.001	37 50 57.497, 122 27 00.081	Blend	2338	Central	62
7/30/2002	2:55	37 48.889, 122 26.725	37 48 53.705, 122 26 42.380	Blend	2316	Central	77
7/30/2002	2:43	38 03.664, 122 00.180	38 03.700, 122 00.211	Fill	1009	Middle Ground	
7/31/2002	5:15	37 49.872, 122 26.051	37 49 47, 122 26 13	Coarse	1841	Central	68
7/31/2002	2:25	37 50 52.045, 122 27 19.351	37 50 52.117, 122 27 19.687	Blend	2286	Central	59
7/31/2002	4:15	37 50.972, 122 25.474	37 51 02.052, 122 25 37.269	Fill	2256	Central	68
7/31/2002	5:30	38 03.712, 121 59.327	38 03.669, 121 59.895	Fill	1592	Middle Ground	21
8/1/2002	3:00	37 50.899, 122 25.886	37 50.815, 122 25.700	Fill	1747	Central	56
8/1/2002	3:30	37 49 54.300, 122 26 23.391	No Data	Coarse	2328	Central	84
8/1/2002	5:50	37 50 37.754, 122 27 23.421	37 50 35.485, 122 27 28.510	Coarse	2273	Central	67
8/2/2002	2:30	37 50.981, 122 25.562	37 50.791, 122 25.797	Fill	1776	Central	61
8/2/2002	7:50	37 49 02.129, 122 27 05.363	37 48 55.391, 122 27 20.412	Blend	1672	Central	78
8/2/2002	4:59	38 03.400, 122 00.600	38 03.650, 121 59.500	Fill	1279	Middle Ground	
8/3/2002	5:00	37 49 54.801, 122 26 09.971	37 49.896, 122 26.068	Coarse	1943	Central	76
8/4/2002	3:59	38 03.59, 121 59.65	38 03.56, 121 58.85	Fill	1570	Middle Ground	
8/4/2002	3:45	37 49 21.57, 122 26 18.42	37 49 21.64, 122 26 08.19	Medium	1868	Central	63
8/5/2002	4:30	37 49.742, 122 27.096	37 49.828, 122 26.270	Coarse	1612	Central	
8/5/2002	5:30	37 50.139, 122 26.166	37 49.949, 122 26.127	Coarse	2199	Central	
8/5/2002	4:35	37 49 52.935, 122 27 05.035	37 49.888, 122 27.101	Coarse	2335	Central	84
8/5/2002	0:00	38 03.625, 121 59.306	38 03.587, 121 59.150	Fill	981	Middle Ground	41
8/6/2002	2:00	38 02.790, 121 54.290	38 62.799, 121 54.284	Blend	1780	Suisun Bay	
8/6/2002	4:45	37 49.921, 122 26.102	37 49.920, 122 26.103	Coarse	2246	Central	73
8/6/2002	4:05	37 48.857, 122 26.818	37 48.921, 122 26.728	Blend	2266	Central	77
8/6/2002	3:30	37 49 21.57, 122 26 12.39	37 49 21.54, 122 26 12.58	Medium	1911	Central	75
8/7/2002	7:35	37 52.935, 122 25.086	37 51.025, 122 25.402	Fill	1593	Central	
8/7/2002	6:10	37 50.610, 122 27.075	37 50.623, 122 27.572	Coarse	2329	Central	74
8/7/2002	6:34	38 03.493, 122 36.458	38 03.608, 121 59.330	Fill	1545	Middle Ground	
8/7/2002	3:10	37 49 20.09, 122 26 12.6	37 49 22.43, 122 26 14.00	Medium	2089	Central	71
8/8/2002	4:45	37 48.995, 122 23.260	37 49.920, 122 26.103	Coarse	2158	Central	
8/8/2002	6:25	37 49.997, 122 26.802	37 50.278, 122 26.612	Coarse	2284	Central	
8/8/2002	6:03	38 03.605, 121 59.820	38 03.578, 121 58.905	Fill	1188	Middle Ground	

8/8/2002	4:25	37 49 20.6, 122 26 12.9	37 49 22.5, 122 26 13.9	Medium	1927	Central	72
8/9/2002	1:00	37 50.031, 122 25.975	37 49.926, 122 26.112	Coarse	1095	Central	
8/9/2002	3:55	37 50.900, 122 26.698	37 50.677, 122 27.303	Coarse	2290	Central	46
8/9/2002	4:00	37 49.850, 122 26.715	37 49.854, 122 26.648	Coarse	2319	Central	93
8/10/2002	5:25	38 03.712, 121 59.327	38 03.778, 122 00.656	Fill	1536	Middle Ground	21
8/12/2002	3:30	37 49.906, 122 26.246	37 49.876, 122 26.216	Coarse	1586	Central	79
8/13/2002	3:00	38 02.843, 121 54.759	37 02.857, 122 54.456	Blend	1688	Suisun Bay	39
8/13/2002	5:33	37 49.916, 122 26.039	37 49 48.882, 122 26 07.938	Coarse	1938	Central	78
8/13/2002	7:00	37 50 35.944, 122 27 28.709	37 50.454, 122 27.285	Coarse	2295	Central	71
8/13/2002	4:35	37 50.967, 122 26.585	37 50.137, 122 27.897	Coarse	2310	Central	43
8/14/2002	4:00	37 49.140, 122 27.035	37 49 02.984, 122 27 05.963	Blend	1989	Central	
8/14/2002	4:40	37 49 54.532, 122 26 01.731	37 49 53.857, 122 26 07.544	Coarse	2014	Central	75
8/14/2002	3:40	37 50 58.817, 122 25 49.467	37 50.618, 122 25.425	Fill	2321	Central	52
8/14/2002	4:15	37 50.967, 122 26.585	37 50.137, 122 27.897	Coarse	2322	Central	43
8/14/2002	8:08	38 03.593, 121 59.874	38 03.637, 122 00.194	Fill	1414	Middle Ground	
8/15/2002	2:00	37 50.921, 122 25.897	37 50.773, 122 25.784	Fill	1775	Central	55
8/15/2002	3:35	37 49 55.800, 122 26 01.051	37 49.936, 122 26.090	Coarse	1994	Central	76
8/15/2002	3:35	37 49 54.945, 122 25 59.841	37 49 54.436, 122 26 03.559	Coarse	2084	Central	74
8/15/2002	2:00	37 49.639, 122 27.242	37 49.322, 122 26.588	Blend	2354	Central	
8/15/2002	4:30	37 50.468, 122 26.186	37 50.408, 122 27.270	Coarse	2333	Central	
8/16/2002	2:15	37 50.900, 122 25.922	37 50.753, 122 25.768	Fill	1768	Central	
8/16/2002	4:20	37 50.119, 122 27.157	37 50.172, 122 27.065	Coarse	2303	Central	88
8/16/2002	2:00	37 49.370, 122 27.000	37 49.283, 122 27.046	Blend	2407	Central	87
8/16/2002	6:13	38 03.600, 121 59.744	38 03.669, 121 59.895	Fill	1608	Middle Ground	
8/18/2002	5:40	38 03.600, 121 59.600	38 03.580, 121 58.394	Fill	1549	Middle Ground	
8/19/2002	3:00	37 48.894, 122 26.666	37 48.968, 122 26.759	Blend	2252	Central	76
8/20/2002	3:15	37 49.917, 122 26.049	37 49.810, 122 26.226	Coarse	1622	Central	
8/20/2002	7:00	37 49.952, 122 26.095	37 39 51.675, 122 27 08.111	Coarse	2213	Central	
8/20/2002	3:20	37 49 53.561, 122 26 02.459	37 49 51.046, 122 26 07.415	Coarse	1867	Central	72
8/20/2002	4:15	37 50.773, 122 26.702	37 50.843, 122 27.340	Coarse	2327	Central	56
8/20/2002	5:39	38 03.628, 122 00 007	38 03.570, 121 58.378	Fill	1716	Middle Ground	
8/21/2002	2:45	38 02.817, 121 54.657	38 02.808, 121 54.635	Blend	1555	Suisun Bay	45
8/21/2002	4:14	37 49 57.802, 122 26 12.611	37 49 56.232, 122 26 02.534	Coarse	2115	Central	80
8/21/2002	4:25	37 49.931, 122 26.705	37 49.788, 122 26.644	Coarse	2289	Central	88
8/21/2002	4:40	37 51.001, 122 25.451	37 50.886, 122 25.930	Fill	2318	Central	61
8/21/2002	5:00	38 03.687, 122 00.160	No Data	Fill	1355	Middle Ground	
8/21/2002	3:35	37 49 22.5, 122 26 15.8	37 49 22.5, 122 26 15.8	Medium	1983	Central	67
8/22/2002	4:00	37 49 53.156, 122 26 00.918	37 49 50.907, 122 26 21.569	Coarse	2047	Central	70
8/22/2002	5:45	37 49 50802, 122 26 00.269	37 49 53.224, 122 26 05.140	Coarse	1841	Central	67
8/22/2002	1:30	37 49.833, 122 26.641	37 49.872, 122 26.478	Coarse	2339	Central	83
8/22/2002	3:40	37 48.887, 122 26.877	37 48.855, 122 26.777	Blend	2287	Central	78
8/22/2002	3:30	37 49 22.4, 122 26 15.1	37 49 22.15, 122 26 15.5	Medium	1976	Central	67
8/23/2002	4:58	38 03.692, 122 00.036	38 03.693, 121 59.686	Fill	1481	Middle Ground	
8/23/2002	3:00	37 50.911, 122 26.008	37 50.729, 122 25.791	Fill	1775	Central	
8/23/2002	4:10	37 49.821, 122 26.600	37 49.933, 122 26.446	Coarse	2300	Central	81
8/24/2002	3:50	37 50.634, 122 27.413	37 50.858, 122 27.344	Coarse	2316	Central	71
8/25/2002	4:59	38 03.600, 122 00.400	38 03.600, 121 59.400	Fill	1361	Middle Ground	
8/26/2002	2:53	38 03.642, 121 59.884	38 03.633, 121 58.753	Fill	911	Middle Ground	

8/26/2002	4:40	37 49 54.971, 122 26 15.817	37 49 49.141, 122 26 16.291	Coarse	1897	Central	79
8/27/2002	3:30	37 49.856, 122 26.358	37 49.857, 122 26.458	Coarse	1374	Central	80
8/27/2002	5:15	37 49.877, 122 26.005	37 49.928, 122 26.053	Coarse	1974	Central	69
8/27/2002	5:00	37 49 59.999, 122 26 50.410	37 50 01.927, 122 27 07.951	Coarse	2281	Central	
8/27/2002	4:30	37 50 41.021, 122 27 02.236	37 50 37.388, 122 27 10.885	Coarse	2254	Central	63
8/28/2002	1:45	38 02.867, 121 54.594	38 02.756, 121 55.146	Blend	1688	Suisun Bay	36
8/28/2002	4:45	38 03.650, 121 59.315	No Data	Fill	1345	Middle Ground	37
8/28/2002	1:00	37 49.019, 122 26.506	37 49.025, 122 26.469	Blend	230	Central	67
8/28/2002	4:55	37 49 52.436, 122 26 15.279	37 49.815, 122 26.290	Coarse	1959	Central	76
8/28/2002	2:30	37 49 04.979, 122 27 02.302	37 49 04.710, 122 27 06.109	Blend	2365	Central	84
8/29/2002	4:15	37 50.876, 122 25.664	37 50.803, 122 25.701	Fill	1682	Central	68
8/29/2002	1:00	37 49.877, 122 25.860	37 49.851, 122 26.126	Coarse	333	Central	71
8/29/2002	0:00	No Data	No Data	Coarse	1680	Central	
8/29/2002	2:20	37 49 07.035, 122 27 04.667	37 49 05.305, 122 27 07.011	Blend	2376	Central	90
8/29/2002	2:10	37 49 05.191, 122 27 04.846	37 49 04.778, 122 27 05.793	Blend	2357	Central	90
8/30/2002	3:56	38 03.661, 121 59.751	38 03.683, 121 59069	Fill	1295	Middle Ground	
8/30/2002	5:45	37 49 58.301, 122 26 19.998	37 48.811, 122 26.567	Coarse	2331	Central	85
8/30/2002	5:10	37 50 50.461, 122 27 15.731	37 50 37.157, 122 27 23.976	Coarse	2306	Central	62
8/31/2002	2:30	37 50.874, 122 25.920	37 50.716, 122 25.776	Fill	1789	Central	58
9/1/2002	7:56	33 03.78, 122 00.05	38 03 .593, 122 59.434	Fill	1717	Middle Ground	
9/3/2002	4:15	37 49.859, 122 26.100	37 49.817, 122 26.339	Coarse	1593	Central	72
9/3/2002	6:00	37 49.882, 122 26.163	37 49.824, 122 26.215	Coarse	1773	Central	74
9/3/2002	5:45	37 50 43.130, 122 27 13.323	37 50 41.982, 122 27 27.158	Coarse	2344	Central	66
9/4/2002	7:30	38 03.592, 121 59.752	38 03.767, 121 58.292	Fill	1774	Middle Ground	
9/4/2002	6:05	37 48.7304, 122 26.9853	37 48.8815, 122 26.6240	Blend	1764	Central	55
9/5/2002	3:00	38 03.325, 121 52.535	38 02.850, 121 54.510	Blend	1715	Suisun Bay	
9/5/2002	4:25	38 03.678, 122 00.121	38 03.668, 121 58.531	Fill	1433	Middle Ground	
9/5/2002	6:30	37 49.8961, 122 26.6153	37 50.4762, 122 26.4860	Coarse	1677	Central	83
9/5/2002	4:30	37 49.551, 122 2 6.122	37 49 56.8, 122 26 06.3	Coarse	2090	Central	63
9/5/2002	5:22	37 50 48.753, 122 27 12.098	37 50 41.495, 122 27 27.348	Coarse	2339	Central	62
9/5/2002	3:50	37 48 53.448, 122 26 31.037	37 48 55.296, 122 26 47.237	Blend	2309	Central	85
9/6/2002	5:15	37 50.795, 122 25.635	37 50.569, 122 26.066	Fill	1723	Central	80
9/6/2002	4:10	37 51 5.380, 122 25 23.072	37 51 2.995, 122 25 38.981	Fill	2302	Central	49
9/6/2002	4:05	37 49 53.397, 122 26 31.919	37 49 50.012, 122 26 35.531	Coarse	2324	Central	86
9/7/2002	5:11	38 03.653, 121 59.852	38 03.659, 121 59..678	Fill	1633	Middle Ground	
9/8/2002	5:10	38 03.565, 121 59.977	38 03.450, 121 59.995	Fill	1520	Middle Ground	
9/9/2002	2:30	37 50.802, 122 25.917	37 50.692, 122 25.743	Fill	1663	Central	62
9/9/2002	No Data	37 49.842, 122 25.813	37 49.873, 122 26.119	Coarse	1840	Central	71
9/9/2002	4:10	37 49 21.4, 122 26 15.2	37 49 21.4, 122 26 15.2	Medium	1889.73	Central	64
9/10/2002	3:45	37 49.807, 122 26.207	37 49.862, 122 26.130	Coarse	1587	Central	70
9/10/2002	3:20	38 03.604, 121 59.945	38 03.632, 121 58.660	Fill	1020	Middle Ground	
9/10/2002	No Data	37 49.763, 122 26.204	37 49.849, 122 26.037	Coarse	1903	Central	74
9/10/2002	4:45	37 49 46.157, 122 27 05.368	37 49 50.974, 122 27 05.208	Coarse	2273	Central	70
9/10/2002	2:30	37 49 21.3, 122 26 13.5	37 49 21.2, 122 26 13.5	Medium	1800.86	Central	71
9/11/2002	2:00	38 02.834, 121 54.636	38 02.837, 121 54.639	Blend	1776	Suisun Bay	45
9/11/2002	3:49	38 03.300, 121 57.309	38 03.274, 121 57.253	Fill	1102	Middle Ground	
9/11/2002	No Data	37 49.877, 122 25.831	37 49.843, 122 26.178	Coarse	1618	Central	70
9/11/2002	6:03	37 50 41.134, 122 27 04.730	37 50 39.048, 122 27 23.099	Coarse	2325	Central	68

9/11/2002	3:15	37 49 5.080, 122 27 1.550	37 49 0.628	Blend	2353	Central	82
9/11/2002	5:15	37 49 22.58, 122 26 13.32	37 49 22.38, 122 26 1332	Medium	1820.24	Central	73
9/12/2002	5:07	38 03.662, 121 58.705	No Data	Fill	1523	Middle Ground	
9/12/2002	No Data	37 49.843, 122 26.144	37 49.820, 122 26.195	Coarse	1938	Central	75
9/13/2002	2:45	37 50.757, 122 25.891	37 50.853, 122 25.598	Fill	1790	Central	68
9/13/2002	5:00	38 03.625, 122 00.115	38 03.677, 122 00.020	Fill	1521	Middle Ground	
9/13/2002	No Data	37 49.864, 122 26.125	37 49.798, 122 25.988	Coarse	1885	Central	74
9/13/2002	3:55	37 50 41.966, 122 26 44.743	37 50 41.047, 122 26 46.292	Coarse	2323	Central	60
9/13/2002	2:50	37 49 4.235, 122 27 3.772	37 49 6.950, 122 27 3.926	Blend	2401	Central	85
9/13/2002	4:20	37 49 55.954, 122 26 2.962	37 49 52.519, 122 26 32.219	Coarse	2314	Central	74
9/14/2002	No Data	No Data	No Data	Coarse	1821	Central	
9/15/2002	5:03	38 03.703, 122 00.392	38 03.640, 121 59.093	Fill	1622	Middle Ground	
9/16/2002	3:45	37 49.851, 122 26.030	37 49.967, 122 26.057	Coarse	1552	Central	69
9/16/2002	5:01	38 03.669, 122 00.216	38 03.699, 121 58.792	Fill	1361	Middle Ground	
9/16/2002	5:00	37 50.398, 122 26.527	37 49.785, 122 26.092	Coarse	1880	Central	81
9/17/2002	2:00	38 02.817, 121 54.620	38 02.859, 121 54.577	Blend	1768	Suisun Bay	51
9/17/2002	6:45	37 48 5.34, 122 27 1.62	37 49 2.30, 122 27 4.63	Blend	2066	Central	
9/18/2002	2:45	37 50.821, 122 25.897	37 50.727, 122 25.704	Fill	1780	Central	61
9/18/2002	5:14	38 03.582, 121 58.700	38 03.667, 121 58.535	Fill	1397	Middle Ground	
9/18/2002	6:15	37 49 51.231, 122 26 17.363	37 49 57.109, 122 26 13.623	Coarse	1960	Central	75
9/18/2002	5:15	37 49 50.513, 122 26 36.538	37 49 48.323, 122 26 38.368	Coarse	2371	Central	82
9/19/2002	4:22	38 03.579, 121 58.665	38 03.667, 121 59.469	Fill	1429	Middle Ground	
9/19/2002	1:00	37 49 07.788, 122 27 01.100	37 49 05.630, 122 27 04.936	Blend	308	Central	84
9/19/2002	5:00	37 49 50.82, 122 26 8.13	37 49 50.43, 122 26 1.45	Coarse	2141	Central	74
9/19/2002	4:50	37 49 51.908, 122 26 27.411	37 49 53.448, 122 26 44.194	Coarse	2323	Central	84
9/19/2002	5:35	37 50 36.027, 122 27 25.116	37 50 44.498, 122 27 21.924	Coarse	2297	Central	72
9/20/2002	5:30	37 49 54.825, 122 26 2.635	37 49 49.450, 122 26 7.180	Coarse	1998	Central	78
9/20/2002	5:05	37 51 2.871, 122 25 25.044	37 50 0.926, 122 25 43.070	Fill	2313	Central	58
9/20/2002	3:50	37 50 47.026, 122 27 14.632	37 50 40.383, 122 27 19.360	Coarse	2297	Central	59
9/20/2002	3:35	37 48 54.997, 122 26 47.030	37 48 53.706, 122 26 48.064	Blend	2267	Central	80
9/22/2002	5:32	38 03.630, 122 00.021	38 03.317, 121 57.864	Fill	1573	Middle Ground	
9/24/2002	4:15	37 48.857, 122 26.183	37 49.936, 122 26.209	Coarse	1608	Central	
9/24/2002	4:36	38 03.500, 121 59.501	38 03.643, 121 58.840	Fill	1502	Middle Ground	
9/24/2002	4:17	37 50 10.5, 122 27 0.121	37 49 49.522, 122 27 11.148	Coarse	2288	Central	93
9/25/2002	2:00	38 02.828, 121 54.582	38 02.810, 121 54.575	Blend	1735	Suisun Bay	48
9/25/2002	4:01	38 03.653, 121 59.893	38 03.672, 121 58.668	Fill	1474	Middle Ground	
9/25/2002	5:15	37 51 8.972, 122 25 53.212	37 50 56.640, 122 25 51.750	Fill	2287	Central	66
9/25/2002	1:55	37 49 3.945, 122 26 59.707	37 49 2.925, 122 27 4.103	Blend	2364	Central	80
9/26/2002	4:30	37 50 46.342, 122 26 40.508	37 50 41.351, 122 26 45.220	Coarse	2326	Central	56
9/26/2002	4:20	37 50 15.610, 122 26 19.284	37 50 8332, 122 27 12.077	Coarse	2285	Central	87
9/27/2002	2:20	37 50.768, 122 25.760	37 50.778, 122 25.791	Fill	1747	Central	72
9/27/2002	4:09	38 03.594, 121 59.623	38 03.645, 121 59.872	Fill	1245	Middle Ground	
9/27/2002	5:35	37 49 57.208, 122 26 4.609	37 50 4.555, 122 27 3.588	Coarse	2281	Central	79
9/30/2002	4:20	37 49.843, 122 26.282	37 50.024, 122 26.098	Coarse	1570	Central	72
9/30/2002	4:50	37 50 43.387, 122 27 13.172	37 50 41.803, 122 27 24.101	Coarse	1133	Central	65
9/30/2002	5:30	37 49 22.32, 122 26 12.30	37 49 22.38, 122 26 15.87	Medium	1932.49	Central	73
10/1/2002	1:45	38 02.849, 121 54,411	38 02.854, 121 54.514	Blend	1729	Suisun Bay	37
10/1/2002	4:30	37 49.047, 122 26.977	37 49.112, 122 26.157	Coarse	1930	Central	78

10/1/2002	2:45	37 49 44.058, 122 26 31.750	37 49 53.779, 122 26 33.459	Coarse	2309	Central	59
10/1/2002	4:00	37 50 42.242, 122 27 09.505	37 50 44.011, 122 27 11.400	Coarse	2341	Central	66
10/1/2002	4:30	37 49 22.32, 122 26 13.68	37 49 21.06, 122 26 15.18	Medium	1998.09	Central	72
10/2/2002	2:45	37 50.690, 122 25.844	37 50.828, 122 25.930	Fill	1743	Central	77
10/2/2002	5:36	38 03.619, 121 59.570	38 03.609, 121 58.971	Fill	1422	Middle Ground	
10/2/2002	5:50	37 49.923, 122 26.174	37 49.934, 122 26.073	Coarse	1688	Central	79
10/2/2002	2:50	37 48 49.318, 122 26 41194	37 48 51.998, 122 26 38.518	Blend	2303	Central	69
10/2/2002	3:50	37 48 54.827, 122 26 31.414	37 48 55.634, 122 26 45.092	Blend	2335	Central	78
10/2/2002	9:15	37 49 20.82, 122 26 13.56	37 49 20.82, 122 26 13.56	Medium	1985.6	Central	67
10/3/2002	5:15	37 49.375, 122 26.934	37 49.738, 122 26.756	Coarse	1963	Central	
10/3/2002	4:15	37 50 40.612, 122 27 16.404	37 50 44.814, 122 27 13.730	Coarse	2325	Central	66
10/3/2002	4:20	37 49 51.410, 122 26 33.918	37 49 54.224, 122 26 40.581	Coarse	2345	Central	86
10/4/2002	2:15	37 50 53, 122 25 32	37 50.938, 122 25.431	Fill	1728	Central	76
10/4/2002	4:45	No Data	No Data	Blend	2152	Central	
10/4/2002	4:40	37 49 49.849, 122 26 21.290	37 49 52.555, 122 26 40.171	Coarse	2355	Central	76
10/5/2002	6:10	38 03.646, 121 59.986	38 03.412, 121 59.075	Fill	1483	Middle Ground	
10/5/2002	4:25	No Data	No Data	Coarse	2190	Central	
10/7/2002	3:45	37 49.912, 122 26.163	37 49.889, 122 26.104	Coarse	1578	Central	77
10/7/2002	4:31	38 03.641, 121 59.899	38 03.748, 122 00.495	Fill	1443	Middle Ground	
10/7/2002	6:30	37 49 50.013, 122 26 24.458	37 49 51.814, 122 26 13.313	Coarse	1888	Central	79
10/8/2002	2:20	37 50.737, 122 25.880	37 50.746, 122 25.822	Fill	1745	Central	71
10/8/2002	4:56	38 03.698, 122 00.102	38 03.662, 121 58.470	Fill	1601	Middle Ground	
10/8/2002	5:15	37 49.873, 122 26.404	37 48 50.466, 122 26 7.850	Coarse	1990	Central	86
10/8/2002	2:20	37 49 3.645, 122 27 2.285	37 49 0.639, 122 27 11.211	Blend	2308	Central	83
10/8/2002	4:00	37 50 47.078, 122 27 18.410	37 50 39.901, 122 27 28.163	Coarse	2318	Central	62
10/9/2002	5:15	37 49 53.582, 122 26 06.554	37 49 51.404, 122 26 07.204	Coarse	1934	Central	73
10/9/2002	2:50	37 48 56.287, 122 26 40.962	37 49 3.133, 122 26 59.821	Blend	2312	Central	78
10/9/2002	5:05	37 50 6.315, 122 27 5.055	37 50 6.935, 122 27 5.201	Coarse	2320	Central	89
10/10/2002	2:45	38 02.837, 121 54.652	38 02.821, 121 54.532	Blend	1739	Suisun Bay	42
10/10/2002		37 49 49.907, 122 26 18.88	37 49 56.592, 122 26 6.713	Coarse	1761	Central	74
10/10/2002	2:20	37 50 45.510, 122 27 28.370	37 50 49.237, 122 27 23.341	Coarse	2280	Central	62
10/10/2002	3:35	37 50 8.511, 122 27 4.790	37 50 8.618, 122 26 59.938	Coarse	2305	Central	88
10/11/2002	6:02	30 03.609, 121 58.971	30 03.611, 121 59.499	Fill	1671	Middle Ground	
10/12/2002	5:05	37 49 52.389, 122 26 04.773	37 49 49.551, 122 26 10.836	Coarse	1873	Central	71
10/13/2002	6:35	38 03.614, 121 59.328	38 03.519, 121 57.864	Fill	1649	Middle Ground	40
10/14/2002	3:30	37 49.878, 122 26.123	37 49.870, 122 26.392	Coarse	1556	Central	73
10/14/2002	4:35	37 49 54.512, 122 26 26.594	37 49 50.820, 122 26 27.880	Coarse	1904	Central	91
10/14/2002	4:35	37 49 50.338, 122 26 35.158	37 49 50.330, 122 26 35.283	Coarse	2343	Central	83
10/15/2002	2:00	37 50.763, 122 26.079	37 50.635, 122 25.851	Fill	1765	Central	
10/15/2002	5:01	38 03.500, 121 59.300	38 03.689, 121 58.656	Fill	1450	Middle Ground	
10/15/2002	4:55	37 49 50.081, 122 26 2.283	37 49 49.614, 122 26 6.5	Coarse	2019	Central	66
10/15/2002	4:30	37 50 35.574, 122 27 27.451	37 50 35.974, 122 27 21904	Coarse	2339	Central	74
10/15/2002	5:15	37 49.21.12, 122 26 10.62	37 49 21.12, 122 26 10.62	Medium	1873.03	Central	71
10/16/2002	4:01	38 03.013, 121 55.772	38 03.010, 121 56.004	Fill	1368	Suisun Bay	
10/16/2002	5:45	37 49 50.236, 122 26 0.307	37 49 50.860, 122 26 10.560	Coarse	1985	Central	66
10/16/2002	3:15	37 50 25.464, 122 27 15.408	37 50 25.233, 122 27 11.717	Coarse	2328	Central	79
10/16/2002	3:25	37 49 0.076, 122 25 19.413	37 48 57.995, 122 25 45.670	Blend	2252	Central	73
10/16/2002	6:15	37 49 21.9, 122 26 14.8	37 49 21.9, 122 26 14.8	Medium	1631.64	Central	66

10/17/2002	3:00	38 02.797, 121 54.585	38 02.802, 121 54.640	Blend	1798	Suisun Bay	
10/17/2002	6:55	37 49 50.326, 122 26 13.668	37 49 52.255, 122 26 33.540	Coarse	1935	Central	70
10/17/2002	3:05	37 48 56.188, 122 25 28.174	37 48 56.463, 122 25 39.270	Blend	2339	Central	61
10/17/2002	5:10	37 49 50.548, 122 26 30.022	37 49 48985, 122 27 07.432	Fill	2308	Central	78
10/17/2002	7:00	38 02 03.2, 122 09 46.1	38 02 05.9, 122 09 54.9	Fine	2052.95	Carquinez	
10/18/2002	4:40	38 03.600, 121 59.570	38 03.653, 121 58.749	Fill	1341	Middle Ground	
10/18/2002	7:56	38 03.500, 121 59.300	38 03.480, 121 57.780	Fill	1432	Middle Ground	
10/18/2002	6:25	37 49 54.073, 122 26 8.824	37 49 51.337, 122 26 10.384	Coarse	1976	Central	75
10/19/2002	3:05	37 49 5.951, 122 26 30.988	37 49 6.136, 122 26 32.932	Blend	2034	Central	65
10/19/2002	6:00	37 49 50.548, 122 26 30.022	37 49 52.383, 122 26 12.514	Coarse	2261	Central	78
10/21/2002	5:54	38 03.585, 121 59.754	38 03.464, 121 57.800	Fill	1456	Middle Ground	
10/22/2002	3:45	37 50.615, 122 27.697	37 50.569, 122 27.690	Coarse	1575	Central	
10/22/2002	5:47	38 03.670, 121 59.938	38 03.655, 121 58.626	Fill	1663	Middle Ground	
10/22/2002	6:45	37 49 54.675, 122 26 16.504	37 49 53.520, 122 26 09.538	Coarse	1883	Central	79
10/22/2002	5:35	37 49 49.617, 122 26 14.862	37 49 54.947, 122 26 08.594	Coarse	1966	Central	68
10/22/2002	5:05	37 50 38.598, 122 27 25.185	37 50 38.108, 122 27 26.348	Coarse	2290	Central	65
10/22/2002	2:45	37 48 55.917, 122 25 50.443	37 48 57.105, 122 25 52.639	Blend	2335	Central	78
10/23/2002	4:40	37 48 50.092, 122 25 54.150	37 48 59.022, 122 25 43.876	Blend	2360	Central	65
10/23/2002	4:00	37 50 42.174, 122 26 27.162	37 50 32.745, 122 26 54.600	Coarse	2272	Central	64
10/24/2002	3:05	37 50.723, 122 25.825	37 50.641, 122 25.773	Fill	1719	Central	75
10/24/2002	5:34	38 03.548, 121 59.476	33 03.468, 121 57.738	Fill	1520	Middle Ground	
10/24/2002	5:50	37 49 49.745, 122 26 11.777	37 49 50.642, 122 26 09.459	Coarse	1969	Central	72
10/25/2002	5:15	38 03.643, 121 59.842	38 03.400, 121 57.680	Fill	1425	Middle Ground	
10/27/2002	4:02	38 03.677, 122 00.224	38 031.680, 121 58.873	Fill	1320	Middle Ground	
10/28/2002	3:30	37 50.570, 122 26.906	37 50.557, 122 27.575	Coarse	1726	Central	75
10/28/2002	4:35	37 49.450, 122 26.150	37 49.991, 122 26.120	Coarse	1802	Central	63
10/29/2002	2:21	38 03.557, 121 59.700	38 03.438, 121 57.741	Fill	1294	Middle Ground	
10/29/2002	5:22	37 49 55.883, 122 25 58.221	37 49 57.660, 122 26 03.978	Coarse	1530	Central	75
10/29/2002	4:40	37 50.238, 122 27.909	37 50.624, 122 27.448	Coarse	2330	Central	
10/30/2002	7:00	37 50.363, 122 27.155	37 50 30.420, 122 27 02.219	Coarse	1876	Central	75
10/30/2002	4:20	37 48.998, 122 25.781	37 48.967, 122 25.692	Blend	2282	Central	77
10/30/2002	2:35	37 49.000, 122 25.523	37 49.990, 122 25.713	Blend	2326	Central	67
10/31/2002	5:32	38 03.629, 121 59.822	No Data	Fill	1631	Middle Ground	
10/31/2002	8:00	37 50 31.051, 122 27 26.357	37 50 30.822, 122 27 24.345	Coarse	1918	Central	76
10/31/2002	5:00	37 50.226, 122 26.882	37 50.403, 122 27.295	Coarse	2369	Central	
11/1/2002	4:00	37 48.917, 122 25.930	37 49.923, 122 25.392	Fill	1787	Central	73
11/1/2002	6:55	38 03.609, 121 58.968	38 03.422, 121 57.792	Fill	1688	Middle Ground	
11/1/2002	6:40	37 50.583, 122 27.083	37 50.532, 122 27.290	Coarse	2343	Central	72
11/2/2002	3:29	37 48.889, 122 26.014	37 48.856, 122 26.012	Fill	1782	Central	74
11/2/2002	7:20	37 50.649, 122 27.002	37 50.453, 122 27.083	Coarse	2240	Central	68
11/3/2002	5:02	38 03.691, 122 00.162	38 03.462, 121 57.653	Fill	1358	Middle Ground	
11/4/2002	5:01	38 03.624, 121 59.984	38 03.666, 121 58.825	Fill	1594	Middle Ground	
11/4/2002	6:20	37 50 32.300, 122 27 32.600	37 50.273, 122 27.351	Coarse	1423	Central	72
11/4/2002	3:00	38 02 02, 122 09 44.6	38 02 02.9, 122 09 44.6	Fine	1918.45	Carquinez	
11/5/2002	5:55	37 50.328, 122 27.296	37 50 36, 122 27 31	Coarse	1738	Central	82
11/5/2002	5:10	37 50.264, 122 27.278	37 50.374, 122 27.333	Coarse	2329	Central	86
11/5/2002	2:40	37 48.877, 122 26.797	37 48.844, 122 26.77	Fill	2372	Central	77
11/6/2002	2:45	37 48.892, 122 25.743	37 48.850, 122 25.743	Blend	1745	Central	62

11/6/2002	4:26	38 03.268, 122 11.555	38 03.682, 121 58.744	Fill	1310	Middle Ground	
11/6/2002	7:20	37 50.313, 122 27.245	37 50.395, 122 27 342	Coarse	1735	Central	83
11/6/2002	3:40	37 49 21.0, 122 26 16	37 49 22.2, 122 26 16	Medium	1972.9	Central	66
11/6/2002	3:00	37 48.898, 22 25.622	37 48.908, 122 25.688	Blend	2347	Central	62
11/6/2002	4:45	37 50.410, 122 27.192	37 50.465, 122 27.271	Coarse	2296	Central	74
11/7/2002	3:00	37 48.917, 122 25.647	37 48.923, 122 25.479	Blend	2318	Central	69
11/8/2002	6:30	37 50.340, 122 27.214	37 50.340, 122 27.214	Coarse	1185	Central	79
11/8/2002	5:00	37 50.711, 122 26.552	37 50.215, 122 27.196	Coarse	2185	Central	62
11/9/2002	5:22	38 03.605, 121 59.600	38 03.500, 121 57.863	Fill	1655	Middle Ground	
11/10/2002	6:00	38 03.344, 121 59.883	38 03.607, 121 59.111	Fill	1509	Middle Ground	
11/11/2002	2:45	37 49.099, 122 26.506	37 49.079, 122 26.992	Fill	1743	Central	64
11/11/2002	7:15	37 50 44.463, 122 26 17.305	37 50 43.111, 122 77 30.960	Coarse	1441	Central	59
11/11/2002	6:05	37 50 25.429, 122 27 4.571	37 50 28.253, 122 27 23.361	Coarse	2303	Central	70
11/12/2002	3:45	37 50.619, 122 27.909	37 50.438, 122 27.763	Coarse	1541	Central	
11/12/2002	2:18	38 03.165, 121 56.362	38 03.044, 121 56.113	Fill	818	Suisun Bay	
11/12/2002	7:30	37 50 33.034, 122 27 34.044	37 50 32.420, 122 27 32.590	Coarse	1471	Central	70
11/13/2002	5:20	38 03.657, 121 58.671	38 03.564, 121 59.824	Fill	1423	Middle Ground	
11/13/2002	6:15	37 50 43.111, 122 27 30.960	37 50 34.877, 122 27 32.402	Coarse	1078	Central	63
11/13/2002	4:25	37 50 33.674, 122 26 42.929	37 50 29.877, 122 27 41.109	Coarse	2334	Central	71
11/14/2002	2:40	37 48.888, 122 25.790	37 48.880, 122 25.776	Blend	1721	Central	68
11/14/2002	4:40	37 50 29.851, 122 26 43.764	37 50 30.958, 122 26 57.783	Coarse	2275	Central	73
11/14/2002	2:50	37 48 49.768, 122 25 57.734	37 48 57.121, 122 25 44.812	Blend	2332	Central	66
11/15/2002	4:09	38 03.573, 121 59.631	No Data	Fill	1321	Middle Ground	
11/15/2002	5:00	37 50 32.024, 122 26 42.661	37 50 26.766, 122 27 3.459	Coarse	2314	Central	71
11/16/2002	2:15	37 49.086, 122 26.506	37 49.079, 122 26.992	Fill	1766	Central	63
11/16/2002	4:41	38 03.596, 121 59.174	38 03.491, 121 57.691	Fill	1425	Middle Ground	40
11/16/2002	3:25	37 48 52.099, 122 25 31.110	37 48 56.808, 122 25 57.471	Blend	2320	Central	53
11/18/2002	4:57	38 03.116, 121 59.956	38 03.594, 121 58.958	Fill	1134	Middle Ground	
11/18/2002	5:05	37 49 21.35, 122 26 16.52	37 49 21.35, 122 26 16.52	Medium	1765.44	Central	66
11/19/2002	3:00	37 49 5.185, 122 27 3.041	37 49 3.491, 122 27 4.972	Fill	1730	Central	85
11/19/2002	0:05	38 03.610, 122 01.505	38 03.646, 121 58.524	Fill	1651	Middle Ground	
11/19/2002	4:55	37 49 22.6, 122 26 21.0	37 49 21.6, 122 26 05.5	Medium	2026.72	Central	67
11/19/2002	5:05	37 50 29.040, 122 27 2.602	37 50 26.338, 122 27 15.075	Coarse	2203	Central	71
11/19/2002	6:30	37 50 23.777, 122 27 1.136	37 50 33.448, 122 27 38.511	Coarse	2272	Central	73
11/20/2002	2:30	37 48.801, 122 26.655	37 48.855, 122 26.747	Fill	1638	Central	69
11/20/2002	7:20	37 50.530, 122 27.329	37 50.726, 122 27.529	Coarse	1856	Central	83
11/20/2002	5:40	37 50 26.664, 122 27 10.000	37 50 27.991, 122 27 35.858	Coarse	2327	Central	75
11/21/2002	4:52	38 03.607, 121 59.893	38.03.478, 121 57.635	Fill	1544	Middle Ground	
11/21/2002	6:55	37 50.620, 122 27.520	37 50.746, 122 27.522	Coarse	1569	Central	66
11/21/2002	3:05	37 49 3.003, 122 27 3.076	37 49 3.855, 122 27 4.931	Fill	2335	Central	82
11/21/2002	6:20	37 50 43.916, 122 26 16.145	37 50 38.701, 122 26 41.589	Coarse	2364	Central	58
11/22/2002	4:00	37 50.555, 122 27.538	37 50.569, 122 27.232	Coarse	1399	Central	73
11/22/2002	5:35	38 03.651, 121 59.919	38 03.603, 121 59.103	Fill	1452	Middle Ground	
11/22/2002	7:55	37 50.651, 122 27.553	37 50.542, 122 27.296	Coarse	1454	Central	64
11/22/2002	4:30	37 50 38.662, 122 26 27.190	37 50 35.164, 122 26 40.850	Coarse	2301	Central	66
11/23/2002	8:05	37 48.828, 122 27.274	37 48.808, 122 27.328	Blend	1747	Central	65
11/24/2002	3:54	38 03.614, 121 59.421	38 03.471, 121 57.811	Fill	1207	Middle Ground	41
11/25/2002	4:36	38 03.621, 121 59.584	38 03.668, 121 58.725	Fill	1299	Middle Ground	

11/25/2002	6:50	37 50.433, 122 27.295	37 50.506, 122 26.917	Coarse	1050	Central	78
11/26/2002	2:20	37 48.848, 122 27.206	37 48.836, 122 26.985	Fill	1716	Central	69
11/26/2002	7:45	37 48.795, 122 27.172	37 48.841, 122 27.057	Coarse	1718	Central	61
11/26/2002	5:30	37 50 23.113, 122 27 00.480	37 50 32.580, 122 26 55.191	Coarse	2343	Central	75
11/26/2002	3:25	37 48 59.550, 122 25 38.554	37 48 57.977, 122 25 43.989	Blend	2335	Central	82
11/27/2002	2:45	No Data	No Data	Fill	1740	Central	
11/27/2002	7:35	37 50 43.257, 122 26 14.930	37 50 40.827, 122 26 29.809	Coarse	1720	Central	58
11/27/2002	3:50	37 48 59.186, 122 25 37.955	37 48 56.919, 122 25 37.746	Blend	2344	Central	84
12/1/2002	6:11	38 03.683, 121 59.878	38 03.495, 121 57.698	Fill	1619	Middle Ground	
12/2/2002	4:00	37 50.680, 122 26.639	37 50.672, 122 26.457	Coarse	1756	Central	65
12/2/2002	3:00	37 48.805, 122 25.886	37 48.799, 122 25.838	Blend	1815	Central	
12/2/2002	6:05	37 50 27.564, 122 27 04.707	37 50 29.536, 122 26 45.410	Coarse	1880	Central	70
12/2/2002	4:50	37 50 30.444, 122 27 12.252	37 50 31.765, 122 26 49.749	Coarse	2286	Central	69
12/2/2002	6:55	37 49 19.51, 122 26 09.21	37 49 19.25, 122 26 24.26	Medium	2032.02	Central	68
12/3/2002	5:15	38 03.612, 121 59.912	38 03.658, 121 58.623	Fill	1565	Middle Ground	
12/3/2002	8:45	37 50 30.919, 122 27 24.775	37 50 31.137, 122 27 21.880	Coarse	1530	Central	74
12/3/2002	3:35	37 48 57.214, 122 25 55.479	37 48 58.055, 122 25 55.677	Blend	2287	Central	79
12/3/2002	6:00	37 49 03.86, 122 09 44.73	38 02 03.66, 122 09 49.02	Fine	1947.53	Carquinez	
12/4/2002	4:50	37 50 32.873, 122 26 49.776	37 50 36.628, 122 26 41.937	Coarse	2235	Central	74
12/4/2002	3:55	37 50 36.719, 122 26 30.376	37 50 39.255, 1222 26 39.156	Coarse	2275	Central	68
12/5/2002	2:30	37 49.005, 122 27.031	37 49.029, 122 27.055	Fill	1812	Central	78
12/5/2002	5:21	38 03.641, 121 59.614	38 03.646, 121 28.373	Fill	1562	Middle Ground	
12/5/2002	2:45	37 49 6.144, 122 27 04.128	37 48 58.202, 122 26 56.998	Blend	2305	Central	88
12/5/2002	3:40	37 48 53.121, 122 25 28.872	37 49 01.313, 122 25 39905	Blend	2288	Central	55
12/6/2002	3:30	37 49.106, 122 27.027	37 49.101, 122 27.083	Fill	1787	Central	85
12/6/2002	4:10	37 50 42.429, 122 26 30.265	37 50 31.633, 122 26 46.204	Coarse	2314	Central	64
12/7/2002	4:00	37 50.760, 122 26.265	37 50.917, 122 27.235	Coarse	1714	Central	58
12/7/2002	8:27	38 03.630, 121 59.925	38 03.474, 121 57.739	Fill	1679	Middle Ground	
12/7/2002	5:10	37 48 43.734, 122 27 34.872	37 48 53.644, 122 27 02.735	Fill	2421	Central	54
12/9/2002	2:30	37 48.829, 122 25.952	37 48.843, 122 25.902	Blend	1792	Central	66
12/9/2002	7:10	37 50 35.089, 122 26 57.186	37 50 32.421, 122 27 37.911	Coarse	2342	Central	73
12/10/2002	6:00	No Data	No Data	Coarse	2157	Central	
12/10/2002	4:30	37 50 32.548, 122 27 12.212	37 50 26.224, 122 27 17.360	Coarse	2348	Central	77
12/10/2002	3:35	37 48 58.418, 122 25 31.371	37 49 00.618, 122 25 42.155	Blend	2346	Central	63
12/11/2002	4:00	37 48.818, 122 26.736	37 48.830, 122 26.827	Fill	1733	Central	70
12/11/2002	7:30	No Data	No Data	Coarse	2034	Central	
12/11/2002	5:35	37 50 28.255, 122 27 23.598	37 50 23.076, 122 27 14.233	Coarse	2278	Central	83
12/12/2002	4:15	37 50.570, 122 27.496	37 50.774, 122 27642	Coarse	1510	Central	75
12/12/2002	7:15	No Data	No Data	Coarse	2055	Central	
12/12/2002	6:35	37 50 31.825, 122 26 49.502	37 50 29.992, 122 27 11.168	Coarse	2252	Central	75
12/13/2002	3:00	37 48.911, 122 26.797	37 48.783, 122 27.055	Fill	1751	Central	77
12/13/2002	5:45	No Data	No Data	Coarse	1956	Central	
12/18/2002	5:45	37 50 31.442, 122 27 07.286	37 50 21.670, 122 27 15.193	Coarse	1636	Central	72
12/18/2002	5:00	37 50 26.690, 122 27 00.357	37 50 26.595, 122 26.515	Coarse	2265	Central	68
12/18/2002	6:30	37 49 20.52, 122 26 16.66	37 49 21.58, 122 26 15.87	Medium	1990.9	Central	67
12/19/2002	2:45	37 50.874, 122 26.923	37 50.659, 122 26.688	Coarse	1650	Central	59
12/19/2002	4:45	37 50 35.219, 122 26 51.354	37 50 34.996, 122 26 00.864	Coarse	1864	Central	72

12/19/2002	3:45	37 50 24.239, 122 27 40.964	37 50.601, 122 26.652	Coarse	2411	Central	
12/19/2002	4:00	38 02 03.36, 122 09 45.69	38 02 04.55, 122 09 47.18	Fine	1942.51	Carquinez	
12/20/2002	3:25	37 49 02.730, 122 27 00.773	37 49 59.402, 122 27 07.126	Blend	1981	Central	79
12/20/2002	4:25	37 50 35.528, 122 27 00.050	37 50 27.190, 122 26 47.899	Coarse	2339	Central	70
12/20/2002	4:10	37 50 36.612, 122 26 34.382	37 50 31.400, 122 26 54.003	Coarse	2286	Central	68
12/21/2002	5:30	37 50 28.792, 122 27 12.210	37 50 33.513, 122 27 05.990	Coarse	1799	Central	76
12/23/2002	4:45	37 50 32.729, 122 26 44.195	37 50 34.919, 122 26 31.728	Coarse	2006	Central	72
12/26/2002	5:00	37 50 39.508, 122 26 22.823	37 50 33.050, 122 26 44.550	Coarse	2109	Central	65
12/27/2002	4:30	37 49 00.825, 122 26 34.619	37 49 06.577, 122 26 30.834	Blend	2099	Central	72
12/27/2002	4:40	37 50 33.283, 122 26 42.081	37 50 29.192, 122 27 02.661	Coarse	2302	Central	70
1/2/2003	6:30	37 50 25.423, 122 27 12.974	37 50 27.561, 122 27 04.135	Coarse	1107	Central	76
1/2/2003	3:55	37 50 31.785, 122 26 39.986	37 50 36.293, 122 26 40.222	Coarse	2381	Central	70
1/3/2003	6:45	37 50 24.344, 122 27 11.567	37 50 21.645, 122 27 00.536	Coarse	1836	Central	74
1/3/2003	2:45	38 48 57.207, 122 25 33.263	37 48 58.901, 122 25 26.433	Blend	2302	Central	66
1/7/2003	3:30	37 50.641, 122 27.623	37 50.688, 122 27.587	Coarse	1507	Central	66
1/7/2003	5:40	37 49 59.537, 122 26 30.698	37 49 54.638, 122 25 58.659	Coarse	2327	Central	
1/7/2003	4:25	37 50 34.968, 122 26 49.396	37 50 29.869, 122 26 51.904	Coarse	2382	Central	71
1/8/2003	2:15	38 02.810, 121 54.589	38 02.829, 121 54.545	Blend	1703	Suisun Bay	50
1/8/2003	3:40	37 48 59.907, 122 25 38.669	37 49 01.369, 122 25 32.272	Blend	2296	Central	81
1/9/2003	5:29	38 03.111, 121 56.302	38 02.865, 121 54.386	Fill	1657	Suisun Bay	
1/9/2003	3:10	37 50 45.198, 122 27 13.065	37 50 43.566, 122 27 16576	Coarse	2333	Central	67
1/10/2003	4:45	No Data	No Data	Coarse	2083	Central	
1/10/2003	5:50	37 50 35.102, 122 26 54.942	37 50 29.128, 122 27 03.343	Coarse	2345	Central	73
1/11/2003	4:44	37 49.882, 122 26.286	37 49.856, 122 26.136	Coarse	1918	Central	78
1/13/2003	5:58	38 03.138, 121 56.199	38 03.007, 121 55.874	Fill	1707	Suisun Bay	
1/13/2003	4:00	37 49.027, 122 26.970	37 49.064, 122 27.110	Blend	1937	Central	83
1/14/2003	2:10	37 48 54.209, 122 26 56.421	37 48 54.621, 122 26 58.933	Fill	2314	Central	77
1/14/2003	4:00	37 48 59.151, 122 25 28.350	37 48 58.343, 122 25 39.864	Blend	2336	Central	68
1/15/2003	5:54	38 03.166, 121 56.274	38 03.057, 121 56.043	Fill	1592	Suisun Bay	
1/15/2003	6:02	No Data	37 50 46.508, 122 26 23.539	Coarse	1840	Central	
1/15/2003	4:55	37 50 38.236, 122 27 24.673	37 50 36.222, 122 27 25.697	Coarse	2032	Central	70
1/15/2003	4:25	37 50 39.525, 122 27 27.683	37 50 45.819, 122 27 26.540	Coarse	2319	Central	63
1/16/2003	4:08	37 48 51.008, 122 27 19.274	37 48 59.752, 122 26 58.233	Fill	1665	Central	67
1/16/2003	4:15	37 50 27.425, 122 26 53.576	37 50 29.038, 122 26 47.644	Coarse	2329	Central	75
1/17/2003	4:15	38 03.105, 121 56.257	38 02.864, 121 54 .690	Fill	1527	Suisun Bay	
1/17/2003	4:10	37 50 27.889, 122 27 20260	37 50 33.405, 122 26 52.160	Coarse	2324	Central	81
1/17/2003	3:30	37 50 40.351, 122 27 04.314	37 50 43.200, 122 27 05.992	Coarse	2320	Central	67
1/20/2003	6:40	37 50 43.989, 122 26 53.333	37 50 52.527, 122 26 49.140	Coarse	2050	Central	56
1/21/2003	3:00	37 50 40.826, 122 26 43.103	37 50 41.483, 122 26 49.376	Coarse	1058	Central	60
1/21/2003	3:00	38 02 54.873, 121 54 45.508	38 02 52.903, 122 54 26.814	Blend	1415	Suisun Bay	34
1/21/2003	5:00	37 50 34873, 122 26 55.314	37 50 27.154, 122 27 04.106	Coarse	2321	Central	79
1/21/2003	3:05	37 50 53.283, 122 26 58.674	37 50 46.840, 122 27 08.130	Coarse	2326	Central	57
1/22/2003	4:30	37 50 38.767, 122 27 35.145	37 50 42.339, 122 27 18.924	Coarse	2008	Central	65
1/23/2003	4:30	37 50 42.525, 122 27 23.423	37 50 46.755, 122 27 23.428	Coarse	2339	Central	64
1/23/2003	4:00	37 49 21.06, 122 26 16.44	37 49 2136, 122 26 16.62	Medium	2010.84	Central	67
1/24/2003	3:20	37 48 56.009, 122 25 45.381	37 48 56.806, 122 25 45.835	Blend	2338	Central	74
1/27/2003	4:26	38 03.164, 121 56.222	38 03.027, 121 55.886	Fill	1665	Suisun Bay	
1/27/2003	4:50	37 50 37.956, 122 27 03.528	37 50 35.167, 122 27 18.033	Coarse	1937	Central	72

1/27/2003	8:05	37 49 22.44, 122 26 15.96	37 49 22.44, 122 26 15.96	Medium	1952.28	Central	65
1/28/2003	4:45	37 49 48.009, 122 26 15.881	37 49 54.819, 122 26 07.719	Coarse	1236	Central	
1/28/2003	4:15	37 50 35.644, 122 27 23.390	37 50 44.480, 122 27 16.178	Coarse	2031	Central	72
1/28/2003	5:40	37 50 25.157, 122 27 07.604	37 50 29.045, 122 26 47.560	Coarse	2262	Central	70
1/28/2003	4:15	37 49 20.30, 122 26 20.70	37 49 20.30, 122 26 20.70	Medium	1566.15	Central	65
1/29/2003	4:24	38 03.155, 121 56.182	38 03.183, 121 56.291	Fill	1575	Suisun Bay	
1/29/2003	2:15	38 02 49.110, 121 55 05.553	38 02 49.229, 121 55 02.476	Blend	1610	Suisun Bay	44
1/29/2003	4:10	37 50 38.914, 122 27 02.048	37 50 43.177, 122 27 05.101	Coarse	2321	Central	70
1/29/2003	4:55	37 50 22.739, 122 26 59.002	37 50 33.210, 122 26 38.481	Coarse	2318	Central	80
1/29/2003	2:10	38 02 03.26, 122 09 45.09	38 02 03.26, 122 09 45.09	Fine	2098.72	Carquinez	
1/30/2003	5:15	37 50 41.800, 122 27 24.131	37 50 35.832, 122 27 20.761	Coarse	1989	Central	63
1/30/2003	2:40	37 49 01.158, 122 26 59.417	37 49 02.206, 122 27 03.803	Fill	2363	Central	78
1/31/2003	4:55	37 49 03.075, 122 27 02.417	37 49 4.619, 122 26 33.485	Blend	2041	Central	81
2/2/2003	7:41	38 03.360, 121 57.197	38 02.866, 121 54.299	Fill	1642	Middle Ground	
2/3/2003	5:06	38 03.369, 121 56.977	38 02.914, 121 54.128	Fill	1687	Middle Ground	
2/3/2003	5:10	37 50.187, 122 26.833	37 50 43.833, 122 27 13.375	Coarse	2079	Central	
2/4/2003	3:29	38 03.197, 121 56.321	38 03.055, 121 55.966	Fill	1431	Middle Ground	
2/4/2003	5:47	37 50.660, 122 26.914	37 50 47.395, 122 27 17.000	Coarse	1973	Central	68
2/4/2003	4:25	37 50 36.120, 122 26 53.401	37 50 31.242, 122 26 54.167	Coarse	2315	Central	72
2/5/2003	2:40	37 48.768, 122 27.126	37 48.753, 122 27.150	Fill	1588	Central	58
2/5/2003	3:55	37 48 59.415, 122 25 44.010	37, 48 57.402, 122 25 32.173	Blend	2326	Central	75
2/6/2003	3:01	38 03.138, 121 56.289	38 02.851, 121 54.677	Fill	1336	Suisun Bay	
2/6/2003	4:25	37 50.720, 122 27.231	37 50.801, 122 27.264	Coarse	2184	Central	66
2/6/2003	4:40	37 50 41.255, 122 27 28.359	37 50 43.559, 122 27 15.286	Coarse	2293	Central	64
2/7/2003	2:30	37 48.774, 122 27.358	37 48 47.240, 122 27 20.218	Fill	1701	Central	57
2/7/2003	4:35	37 50 41.770, 122 27 20.445	37 50 39.360, 122 27.600	Coarse	2341	Central	64
2/8/2003	3:55	37 48 59.217, 122 26 33.640	37 48 58.428, 122 26 49.190	Blend	2340	Central	74
2/10/2003	6:38	38 02.928, 121 55.423	38 02.837, 121 55.500	Fill	1293	Suisun Bay	
2/10/2003	5:10	37 48 51.726, 122 25 26.873	37 48 55.080, 122 25 36.883	Blend	1954	Central	53
2/10/2003	3:35	37 50 41.600, 122 27 14.755	37 50 39.948, 122 27 09.309	Coarse	2304	Central	66
2/11/2003	3:50	37 50 36.624, 122 27 26.558	37 50 45.241, 122 27 23.195	Coarse	1379	Central	70
2/12/2003	5:26	38 03.640, 121 59.883	38 03.515, 121 59.753	Fill	1604	Middle Ground	
2/12/2003	6:40	37 50.689, 122 27.148	37 50.665, 122 27.506	Coarse	1758	Central	67
2/12/2003	2:35	37 48 50.870, 122 26 51.666	37 48 51.692, 122 26 48.176	Fill	2368	Central	78
2/12/2003	3:15	37 48 50.050, 122 25.39756	37 48.992, 122 25.702	Blend	2324	Central	52
2/13/2003	5:20	37 49.033, 122 26.560	37 49.007, 122 26.684	Fill	1575	Central	69
2/13/2003	3:30	37 50.740, 122 27.387	37 50.722, 122 27.440	Coarse	2310	Central	60
2/14/2003	6:05	38 03.648, 121 59.000	38 03.528, 121 58.973	Fill	1553	Middle Ground	
2/14/2003	4:05	37 48.971, 122 27.050	37 48.949, 122 26.952	Fill	1547	Central	78
2/14/2003	4:05	37 50.702, 122 27.365	37 50.717, 122 27.425	Coarse	2307	Central	61
2/18/2003	5:42	38 03.643, 121 58.796	38 03.617, 121 59.097	Fill	1659	Middle Ground	
2/18/2003	5:15	37 50.430, 122 27.166	37 50.439, 122 27.086	Coarse	2319	Central	71
2/19/2003	6:10	38 03.573, 121 59.532	38 03.634, 121 58.792	Fill	1636	Middle Ground	
2/19/2003	3:25	38 02 04.2, 122 09 48.0	38 02 04.2, 122 09 48.0	Fine	2003.38	Carquinez	
2/20/2003	4:30	37 50 38.210, 122 27 26.401	37 50 54.660, 122 27 12.147	Coarse	1600	Central	64
2/20/2003	4:35	37 50.741, 122 27.382	37 50.630, 122 27.343	Coarse	2307	Central	61
2/20/2003	3:10	37 48.940, 122 26.903	37 48.889, 122 26.831	Blend	2261	Central	76
2/21/2003	3:21	38 03.519, 121 58.896	38 03500, 121 58.750	Fill	885	Middle Ground	
2/21/2003	4:40	37 50.640, 122 27.348	37 50.788, 122 27.375	Coarse	2235	Central	67

2/22/2003	3:18	37 50 37.180, 122 27 27.180	37 50.884, 122 27.350	Coarse	1368	Central	70
2/24/2003	3:25	38 03.565, 121 59.686	38 03.498, 121 59.698	Fill	1049	Middle Ground	
2/24/2003	2:25	37 49.012, 122 26.922	37 48.998, 122 26.950	Fill	2286	Central	78
2/24/2003	2:45	37 49 19.6, 122 26 15.7	37 49 19.6, 122 26 15.7	Medium	1994.95	Central	
2/25/2003	4:27	38 03.391, 121 57.602	38 03.463, 121 58.572	Fill	934	Middle Ground	
2/25/2003	6:15	37 50.730, 122 27.249	37 50.716, 122 27.249	Coarse	1883	Central	64
2/25/2003	3:50	37 50.901, 122 27.339	37 50.667, 122 27.420	Coarse	2354	Central	61
2/25/2003	3:00	37 49.037, 122 25.698	37 48.970, 122 25.765	Blend	2291	Central	
2/26/2003	2:48	38 02.852, 121 54.584	38 02.849, 121 54.548	Blend	1490	Suisun Bay	42
2/26/2003	3:20	37 50.138, 122 27.441	37 50.599, 122 26.657	Coarse	2316	Central	
2/26/2003	3:20	37 50.566, 122 26.786	37 50.498, 122 26.897	Coarse	2285	Central	72
2/27/2003	3:31	38 03.651, 121 58.757	38 03.662, 121 00.158	Fill	1092	Middle Ground	
2/27/2003	3:45	37 48.995, 122 26.499	37 48.905, 122 26.586	Fill	1447	Central	71
2/28/2003	5:05	37 50.921, 122 27.078	37 50.765, 122 27.401	Coarse	2017	Central	64
2/28/2003	4:30	37 50.641, 122 27.470	37 50.668, 122 27.446	Coarse	2234	Central	65

APPENDIX D

Summary of SFEI Sediment Sampling Showing Percentage of Sand, Silt, and Clay

SFEI Stations: Proportions of Sand, Silt, Clay

Station Code	Location	Date	Year	Cruise	Latitude N deg	Latitude min	Longitude W deg	Longitude min	Salinity psu	Temp °C	DO mg/L	% Fines (<63 µm) %	% Clay (<4µm) %	% Silt (4µm-63µm) %	% Sand (63µm-2mm) %	% Gravel+Shell (>2mm) %	H20 Depth m	Notes	Ammonia mg/L
BG20	Sacramento River	Sept. 3	1993	1993-03	38	3.36	121	48.63	0	10		34	23	11	66	0	8		
BG20	Sacramento River	Sept. 20	1993	1993-09	38	3.36	121	48.63	0.01	20.6		29	17	12	70	1	8		
BG20	Sacramento River	Feb. 10	1994	1994-02	38	3.36	121	48.63	0.3	9.9	8	31	20	11	69	0	7.8		
BG20	Sacramento River	Aug. 25	1994	1994-08	38	3.36	121	48.63	2.77	21.7	7	50	33	17	50	0	5.3		
BG20	Sacramento River	Feb. 16	1994	1995-02	38	3.36	121	48.63				12	8	4	87	0			0.21
BG20	Sacramento River	Aug. 24	1995	1995-08	38	3.36	121	48.63				27	18	9	73	0			0.53
BG20	Sacramento River	Feb. 15	1996	1996-02	38	3.36	121	48.63				29	14	15	71	0	10		0.2
BG20	Sacramento River	Jan. 30	1997	1997-01	38	3.36	121	48.63				13	7	6	87	0	9		0.2
BG20	Sacramento River	Aug. 6	1996	1996-07	38	3.36	121	48.63				9	5	4	91	0	8		0.2
BG20	Sacramento River	Aug. 7	1997	1997-08	38	3.36	121	48.63				7	4	3	93	0	8		0.3
BG20	Sacramento River	Feb. 5	1998	1998-02	38	3.36	121	48.63				23	11	11	77	0	8		0.2
BG20	Sacramento River	Jul. 30	1998	1998-07	38	3.36	121	48.63				8	4	4	92	0	8		0.2
BG20	Sacramento River	Feb. 11	1999	1999-02	38	3.36	121	48.63				8	5	4	92	0	8		ND
BG20	Sacramento River	Jul. 22	1999	1999-07	38	3.36	121	48.63				8	4	4	92	0	9		3
BG20	Sacramento River	Jul. 20	2000	2000-07	38	3.36	121	48.63				10	5	5	90	0	9		0.4
BG30	San Joaquin River	Mar. 9	1993	1993-03	38	1.36	121	48.44	0	10		28	17	11	72	0	5		
BG30	San Joaquin River	Feb. 10	1994	1994-02	38	1.36	121	48.44	0.54	10.7	9	45	25	20	55	0	5.5		
BG30	San Joaquin River	Aug. 25	1994	1994-08	38	1.36	121	48.44	2.96	22.2	7	34	21	13	66	0	6.8		
BG30	San Joaquin River	Feb. 16	1994	1995-02	38	1.36	121	48.44				64	34	30	36	0			2.74
BG30	San Joaquin River	Aug. 24	1995	1995-08	38	1.36	121	48.44				79	40	39	21	0			0.73
BG30	San Joaquin River	Feb. 15	1996	1996-02	38	1.36	121	48.44				70	34	36	29	0	6		1
BG30	San Joaquin River	Aug. 6	1996	1996-07	38	1.36	121	48.44				67	30	37	33	0	5		0.7
BG30	San Joaquin River	Jan. 30	1997	1997-01	38	1.36	121	48.44				72	37	35	28	0	8		1.6
BG30	San Joaquin River	Aug. 7	1997	1997-08	38	1.36	121	48.44				16	9	7	84	0	5		1.3
BG30	San Joaquin River	Feb. 5	1998	1998-02	38	1.36	121	48.44				70	35	35	30	0	5		1.2
BG30	San Joaquin River	Jul. 30	1998	1998-07	38	1.36	121	48.44				47	26	21	53	0	5		0.4
BG30	San Joaquin River	Feb. 11	1999	1999-02	38	1.36	121	48.44				33	15	18	67	0	5		e 0.1
BG30	San Joaquin River	Jul. 22	1999	1999-07	38	1.36	121	48.44				19	10	9	81	0	8		3
BG30	San Joaquin River	Jul. 20	2000	2000-07	38	1.36	121	48.44				62	31	31	37	0	8		2.2
BF21	Grizzly Bay	Mar. 9	1993	1993-03	38	6.97	122	2.35	0	11.3		99	68	31	2	0	3		
BF21	Grizzly Bay	Sept. 20	1993	1993-09	38	6.97	122	2.35	5.93	18.6		99	66	33	2	0	3		
BF21	Grizzly Bay	Feb. 10	1994	1994-02	38	6.97	122	2.35	5.77	10.6	9	99	68	31	2	0	1.5		
BF21	Grizzly Bay	Aug. 25	1994	1994-08	38	6.97	122	2.35	12.72	20.6	7	98	62	36	1	0	1.5		
BF21	Grizzly Bay	Feb. 16	1994	1995-02	38	6.97	122	2.35				99	62	37	1	0			1.84
BF21	Grizzly Bay	Aug. 24	1995	1995-08	38	6.97	122	2.35				97	63	34	3	1			1.16
BF21	Grizzly Bay	Feb. 15	1996	1996-02	38	6.97	122	2.35				98	58	40	2	0	3		1.2
BF21	Grizzly Bay	Jan. 30	1997	1997-01	38	6.97	122	2.35				99	58	41	1	0	2		0.3
BF21	Grizzly Bay	Aug. 6	1996	1996-07	38	6.97	122	2.35				97	58	39	2	0	3		1.3
BF21	Grizzly Bay	Aug. 7	1997	1997-08	38	6.97	122	2.35				99	62	37	1	0	3		1.9
BF21	Grizzly Bay	Feb. 5	1998	1998-02	38	6.97	122	2.35				99	66	33	1	0	3		2.1
BF21	Grizzly Bay	Jul. 30	1998	1998-07	38	6.97	122	2.35				98	63	35	2	0	3		0
BF21	Grizzly Bay	Feb. 11	1999	1999-02	38	6.97	122	2.35				99	61	38	1	0	3		ND
BF21	Grizzly Bay	Jul. 22	1999	1999-07	38	6.97	122	2.35				97	62	35	3	0	2		1.6
BF21	Grizzly Bay	Jul. 20	2000	2000-07	38	6.97	122	2.35				98	59	39	3	0	2		2.3
BF10	Pacheco Creek	Mar. 10	1993	1993-03	38	2.85	122	5.66	0	11.8		12	8	4	88	0	4		
BF10	Pacheco Creek	Sept. 20	1993	1993-09	38	2.85	122	5.66	11.39	18.8		19	13	6	82	0	4		
BF10	Pacheco Creek	Feb. 10	1994	1994-02	38	2.85	122	5.66	6.47	10.3	9	24	17	7	75	2	2.8		
BF10	Pacheco Creek	Aug. 25	1994	1994-08	38	2.85	122	5.66	18.28	20.5	6	21	13	8	80	0	4.5		
BF10	Pacheco Creek	Feb. 16	1994	1995-02	38	2.85	122	5.66				11	7	4	89	0			0.84
BF10	Pacheco Creek	Aug. 24	1995	1995-08	38	2.85	122	5.66				25	17	8	74	0			0.35
BF10	Pacheco Creek	Feb. 15	1996	1996-02	38	2.85	122	5.66				10	6	4	89	1	5		0.2
BF10	Pacheco Creek	Aug. 6	1996	1996-07	38	2.85	122	5.66				24	16	8	76	0	4		0.1
BF10	Pacheco Creek	Jan. 30	1997	1997-01	38	2.85	122	5.66				13	7	6	87	0	6		0.6
BF10	Pacheco Creek	Aug. 8	1997	1997-08	38	2.85	122	5.66				39	29	9	61	0	4		1.5
BF10	Pacheco Creek	Feb. 5	1998	1998-02	38	2.85	122	5.66				22	11	10	78	0	4		0.1
BF10	Pacheco Creek	Jul. 30	1998	1998-07	38	2.85	122	5.66				18	12	7	63	18	4		0.1
BF10	Pacheco Creek	Feb. 11	1999	1999-02	38	2.85	122	5.66				19	12	7	81	0	4		NA
BF10	Pacheco Creek	Jul. 22	1999	1999-07	38	2.85	122	5.66				27	17	10	73	0	5		1.2
BF10	Pacheco Creek	Jul. 20	2000	2000-07	38	2.85	122	5.66				22	13	9	78	0	6		1.7
BD50	Napa River	Mar. 10	1993	1993-03	38	5.79	122	15.61	4.88	11		94	71	23	3	3	4		
BD50	Napa River	Sept. 21	1993	1993-09	38	5.79	122	15.61	16.04	17.7		99	73	26	2	0	4		

BD50	Napa River	Feb. 11	1994	1994-02	38	5.79	122	15.61	12.24	10.4	9	89	70	19	2	8	2.5	
BD50	Napa River	Aug. 26	1994	1994-08	38	5.79	122	15.61	21.7	20.1	6	91	68	23	3	7	2.5	
BD50	Napa River	Feb. 17	1995	1995-02	38	5.79	122	15.61				93	70	23	4	3		2.72
BD50	Napa River	Aug. 25	1995	1995-08	38	5.79	122	15.61				98	77	21	2	0		0.66
BD50	Napa River	Feb. 16	1996	1996-02	38	5.79	122	15.61				99	76	23	1	0	4	3.2
BD50	Napa River	Aug. 5	1996	1996-07	38	5.79	122	15.61				99	75	24	1	0	4	0.6
BD50	Napa River	Jan. 31	1997	1997-01	38	5.79	122	15.61				96	68	28	4	0	5	3
BD50	Napa River	Aug. 8	1997	1997-08	38	5.79	122	15.61				73	48	25	8	19	4	2.2
BD50	Napa River	Feb. 6	1998	1998-02	38	5.79	122	15.61				74	49	25	26	0	4	0.9
BD50	Napa River	Jul. 31	1998	1998-07	38	5.79	122	15.61				92	65	26	8	0	4	0.8
BD50	Napa River	Feb. 12	1999	1999-02	38	5.79	122	15.61				87	60	27	7	7	4	ND
BD50	Napa River	Jul. 23	1999	1999-07	38	5.79	122	15.61				85	63	22	9	6	2	2.2
BD50	Napa River	Feb. 10	2000	2000-02	38	5.79	122	15.61				96	68	28	3	1	4	2.2
BD50	Napa River	Jul. 21	2000	2000-07	38	5.79	122	15.61				91	59	32	7	1	4	2.1
BD41	Davis Point	Mar. 10	1993	1993-03	38	3.11	122	16.65	8.43	8.6		35	28	7	65	0	6.5	
BD41	Davis Point	Sept. 21	1993	1993-09	38	3.11	122	16.65	19.98	16.1		40	27	13	56	4	6.5	
BD41	Davis Point	Feb. 11	1994	1994-02	38	3.11	122	16.65	16.42	10.5	9	25	17	9	73	2	5.3	
BD41	Davis Point	Aug. 26	1994	1994-08	38	3.11	122	16.65	24.53	19.6	6	16	10	6	81	3	5	
BD41	Davis Point	Feb. 17	1995	1995-02	38	3.11	122	16.65				30	21	9	67	2		1.52
BD41	Davis Point	Aug. 25	1995	1995-08	38	3.11	122	16.65				20	14	6	79	1		0.25
BD41	Davis Point	Aug. 5	1996	1996-07	38	3.11	122	16.65				13	8	5	88	0	6.5	0.1
BD41	Davis Point	Feb. 16	1996	1996-02	38	3.11	122	16.65				18	11	7	83	0	8	0.2
BD41	Davis Point	Jan. 31	1997	1997-01	38	3.11	122	16.65				10	6	4	90	0	7	1
BD41	Davis Point	Aug. 8	1997	1997-08	38	3.11	122	16.65				8	5	3	92	0	6.5	0.7
BD41	Davis Point	Feb. 6	1998	1998-02	38	3.11	122	16.65				33	19	14	67	0	7	0.9
BD41	Davis Point	Jul. 31	1998	1998-07	38	3.11	122	16.65				15	9	5	83	2	7	0.3
BD41	Davis Point	Feb. 12	1999	1999-02	38	3.11	122	16.65				10	6	4	88	2	7	ND
BD41	Davis Point	Jul. 23	1999	1999-07	38	3.11	122	16.65				9	6	4	90	1	7	NS
BD41	Davis Point	Jul. 21	2000	2000-07	38	3.11	122	16.65				20	11	9	79	0	7	1.1
BD41	Davis Point	Feb. 10	2000	2000-02	38	3.11	122	16.65				10	6	4	89	1	7	2
BD31	Pinole Point	Mar. 10	1993	1993-03	38	1.49	122	21.71	9.11	11.7		79	54	25	18	3	6.5	
BD31	Pinole Point	Sept. 21	1993	1993-09	38	1.49	122	21.71	24.44	16.6		88	60	28	12	0	6.5	
BD31	Pinole Point	Feb. 11	1994	1994-02	38	1.49	122	21.71	22.42	11.1	8	84	56	28	15	1	7	
BD31	Pinole Point	Aug. 26	1994	1994-08	38	1.49	122	21.71	28.29	18.6	6	85	58	27	15	0	6.8	
BD31	Pinole Point	Feb. 17	1995	1995-02	38	1.49	122	21.71				94	79	15	6	0		3.37
BD31	Pinole Point	Aug. 25	1995	1995-08	38	1.49	122	21.71				63	43	20	37	0		4.49
BD31	Pinole Point	Feb. 16	1996	1996-02	38	1.49	122	21.71				72	45	27	28	0	8	1.6
BD31	Pinole Point	Aug. 5	1996	1996-07	38	1.49	122	21.71				48	28	20	50	1	6.5	0
BD31	Pinole Point	Jan. 31	1997	1997-01	38	1.49	122	21.71				90	60	29	10	0	7	1.4
BD31	Pinole Point	Aug. 8	1997	1997-08	38	1.49	122	21.71				55	36	18	45	0	6.5	2.6
BD31	Pinole Point	Feb. 6	1998	1998-02	38	1.49	122	21.71				70	39	31	30	0	7	1.9
BD31	Pinole Point	Jul. 31	1998	1998-07	38	1.49	122	21.71				49	31	19	51	0	7	1.2
BD31	Pinole Point	Feb. 12	1999	1999-02	38	1.49	122	21.71				58	34	23	42	0	7	NA
BD31	Pinole Point	Jul. 23	1999	1999-07	38	1.49	122	21.71				91	59	31	9	0	7	6
BD31	Pinole Point	Jul. 21	2000	2000-07	38	1.49	122	21.71				98	61	37	2	0	7	4
BD22	San Pablo Bay	Mar. 10	1993	1993-03	38	2.86	122	25.24	6.08	11.4		NA	NA	NA	NA	NA	3	
BD22	San Pablo Bay	Sept. 21	1993	1993-09	38	2.86	122	25.24	25.73	17.1		91	60	31	8	1	3	
BD22	San Pablo Bay	Feb. 11	1994	1994-02	38	2.86	122	25.24	24.11	11.4	8	91	56	35	8	1	3.8	
BD22	San Pablo Bay	Aug. 26	1994	1994-08	38	2.86	122	25.24	26.24	19.6	6	87	51	36	12	0	3	
BD22	San Pablo Bay	Feb. 17	1995	1995-02	38	2.86	122	25.24				85	52	33	14	2		1.95
BD22	San Pablo Bay	Aug. 25	1995	1995-08	38	2.86	122	25.24				90	57	33	9	1		0.27
BD22	San Pablo Bay	Feb. 16	1996	1996-02	38	2.86	122	25.24				84	53	31	16	1	3	0.2
BD22	San Pablo Bay	Aug. 5	1996	1996-07	38	2.86	122	25.24				89	55	34	11	1	3	0.1
BD22	San Pablo Bay	Jan. 31	1997	1997-01	38	2.86	122	25.24				85	51	35	14	0	2	1.6
BD22	San Pablo Bay	Aug. 8	1997	1997-08	38	2.86	122	25.24				86	52	35	13	0	3	0.2
BD22	San Pablo Bay	Feb. 6	1998	1998-02	38	2.86	122	25.24				88	52	35	12	0	3	0.8
BD22	San Pablo Bay	Jul. 31	1998	1998-07	38	2.86	122	25.24				47	27	20	52	0	3	0.2
BD22	San Pablo Bay	Feb. 12	1999	1999-02	38	2.86	122	25.24				80	49	31	19	1	3	NA
BD22	San Pablo Bay	Jul. 23	1999	1999-07	38	2.86	122	25.24				84	52	32	16	0	4	0.5
BD22	San Pablo Bay	Jul. 21	2000	2000-07	38	2.86	122	25.24				90	56	34	9	1	4	0.9
BD22	San Pablo Bay	Feb. 10	2000	2000-02	38	2.86	122	25.24				88	54	34	12	0	4	0.6
BC21	Horseshoe Bay	Mar. 11	1993	1993-03	37	49.98	122	28.43	24	9.9		88	59	29	12	0	39	
BC21	Horseshoe Bay	Sept. 22	1993	1993-09	37	49.98	122	28.43	33	14		48	32	16	51	1	39	
BC21	Horseshoe Bay	Feb. 14	1994	1994-02	37	49.98	122	28.43	29.89	11.9	8	65	38	27	35	0	12.8	
BC21	Horseshoe Bay	Aug. 29	1994	1994-08	37	49.98	122	28.43	32.32	16.3	6	55	30	25	45	0	9.8	
BC21	Horseshoe Bay	Feb. 20	1995	1995-02	37	49.98	122	28.43				66	38	28	34	0		2.4
BC21	Horseshoe Bay	Aug. 28	1995	1995-08	37	49.98	122	28.43				31	19	12	66	3		0.63
BC21	Horseshoe Bay	Feb. 20	1996	1996-02	37	49.98	122	28.43				30	17	13	40	30	13	0.4
BC21	Horseshoe Bay	Aug. 2	1996	1996-07	37	49.98	122	28.43				41	21	20	59	0	12	1.1
BC21	Horseshoe Bay	Aug. 11	1997	1997-08	37	49.98	122	28.43				34	20	13	66	0	12	1.8
BC21	Horseshoe Bay	Feb. 3	1997	1997-01	37	49.98	122	28.43				48	26	22	52	0	5	0.2
BC21	Horseshoe Bay	Feb. 9	1998	1998-02	37	49.98	122	28.43				43	23	21	57	0	12	0.1

BC21	Horseshoe Bay	Aug. 3	1998	1998-07	37	49.98	122	28.43					26	14	11	74	0	12	0.1
BC21	Horseshoe Bay	Feb. 16	1999	1999-02	37	49.98	122	28.43					23	13	11	77	0	12	ND
BC21	Horseshoe Bay	Jul. 26	1999	1999-07	37	49.98	122	28.43					31	17	14	69	0	10	2.5
BC21	Horseshoe Bay	Jul. 24	2000	2000-07	37	49.98	122	28.43					33	17	16	67	0	12	4
BC11	Yerba Buena Island	Mar. 11	1993	1993-03	37	49.44	122	20.93	16.07	11.2		NA	NA	NA	NA	NA		6	
BC11	Yerba Buena Island	Sept. 22	1993	1993-09	37	49.44	122	20.93	29.62	15.5			79	51	28	19	2	6	
BC11	Yerba Buena Island	Feb. 14	1994	1994-02	37	49.44	122	20.93	27.91	11.6	8		43	32	11	41	17	6	
BC11	Yerba Buena Island	Aug. 29	1994	1994-08	37	49.44	122	20.93	31.55	18.4	7		65	42	23	34	2	5.5	
BC11	Yerba Buena Island	Feb. 20	1995	1995-02	37	49.44	122	20.93					67	46	21	29	3		0.53
BC11	Yerba Buena Island	Aug. 28	1995	1995-08	37	49.44	122	20.93					92	71	21	7	1		1.06
BC11	Yerba Buena Island	Feb. 20	1996	1996-02	37	49.44	122	20.93					78	49	29	21	0	6	0.1
BC11	Yerba Buena Island	Aug. 1	1996	1996-07	37	49.44	122	20.93					61	42	19	29	10	6	0.1
BC11	Yerba Buena Island	Feb. 3	1997	1997-01	37	49.44	122	20.93					70	44	25	27	4	5	0.1
BC11	Yerba Buena Island	Aug. 11	1997	1997-08	37	49.44	122	20.93					38	28	10	58	4	6	0.2
BC11	Yerba Buena Island	Feb. 9	1998	1998-02	37	49.44	122	20.93					74	46	28	26	0	6	0.3
BC11	Yerba Buena Island	Aug. 3	1998	1998-07	37	49.44	122	20.93					78	55	23	17	5	6	0.5
BC11	Yerba Buena Island	Feb. 16	1999	1999-02	37	49.44	122	20.93					70	51	18	23	8	6	ND
BC11	Yerba Buena Island	Jul. 26	1999	1999-07	37	49.44	122	20.93					64	46	18	28	8	6	0.9
BC11	Yerba Buena Island	Jul. 24	2000	2000-07	37	49.44	122	20.93					77	51	26	23	0	6	0.9
BA41	Redwood Creek	Mar. 12	1993	1993-03	37	33.67	122	12.62	17.95	14.3			88	58	30	10	2	2.5	
BA41	Redwood Creek	Feb, 15	1994	1994-02	37	33.67	122	12.62	27.26	11.4	8		88	65	23	10	2	3.3	
BA41	Redwood Creek	Sept. 23	1993	1993-09	37	33.67	122	12.62	28.94	18.6			83	62	21	12	5	2.5	
BA41	Redwood Creek	Aug. 4	1998	1998-07	37	33.67	122	12.62					72	49	23	20	8	3	0.1
BA41	Redwood Creek	Feb. 17	1999	1999-02	37	33.67	122	12.62					70	48	23	9	21	3	ND
BA41	Redwood Creek	Jul. 27	1999	1999-07	37	33.67	122	12.62					70	48	21	16	14	5	0.7
BA41	Redwood Creek	Jul. 25	2000	2000-07	37	33.67	122	12.62					69	49	20	24	7	5	1.2
BA41	Redwood Creek	Feb. 21	1995	1995-02	37	33.67	122	12.62					67	48	19	21	12		0.62
BA41	Redwood Creek	Aug. 29	1995	1995-08	37	33.67	122	12.62					80	58	22	13	7		0.22
BA41	Redwood Creek	Feb. 21	1996	1996-02	37	33.67	122	12.62					88	60	28	8	4	4	0.1
BA41	Redwood Creek	Aug. 1	1996	1996-07	37	33.67	122	12.62					93	65	28	5	1	2.5	0.6
BA41	Redwood Creek	Feb. 4	1997	1997-01	37	33.67	122	12.62					97	69	28	2	1	5	0
BA41	Redwood Creek	Aug. 12	1997	1997-08	37	33.67	122	12.62					76	52	25	16	8	2.5	0.7
BA41	Redwood Creek	Feb. 10	1998	1998-02	37	33.67	122	12.62					97	65	32	3	0	3	0.1
BC41	Point Isabel	Sept. 21	1993	1993-09	37	53.34	122	20.55	29.4	17.1			86	53	33	14	0	1.5	
BC41	Point Isabel	Feb. 14	1994	1994-02	37	53.34	122	20.55	26.82	11.1	8		84	50	34	16	0	2	
BC41	Point Isabel	Aug. 29	1994	1994-08	37	53.34	122	20.55	31.64	17.6	7		87	46	41	13	0	2.3	
BC41	Point Isabel	Feb. 20	1995	1995-02	37	53.34	122	20.55					89	54	35	11	0		0.57
BC41	Point Isabel	Aug. 28	1995	1995-08	37	53.34	122	20.55					88	51	37	12	0		0.54
BC41	Point Isabel	Feb. 16	1996	1996-02	37	53.34	122	20.55					87	47	40	13	0	1	0.2
BC41	Point Isabel	Aug. 2	1996	1996-07	37	53.34	122	20.55					90	56	34	10	0	1.5	5.7
BC41	Point Isabel	Feb. 3	1997	1997-01	37	53.34	122	20.55					89	49	40	11	0	3	1.4
BC41	Point Isabel	Aug. 11	1997	1997-08	37	53.34	122	20.55					92	53	39	8	0	1.5	0.2
BC41	Point Isabel	Feb. 9	1998	1998-02	37	53.34	122	20.55					91	59	32	9	0	2	4.4
BC41	Point Isabel	Aug. 3	1998	1998-07	37	53.34	122	20.55					82	50	33	18	0	2	0.3
BC41	Point Isabel	Feb. 16	1999	1999-02	37	53.34	122	20.55					84	53	31	15	1	2	NA
BC41	Point Isabel	Jul. 26	1999	1999-07	37	53.34	122	20.55					87	57	30	13	0	2	0.7
BC41	Point Isabel	Jul. 24	2000	2000-07	37	53.34	122	20.55					83	50	33	18	0	2	2.2
BB70	Alameda	Feb, 15	1994	1994-02	37	44.84	122	19.40	27.64	11.5	8		82	56	26	18	0	8.8	
BB70	Alameda	Feb. 21	1995	1995-02	37	44.84	122	19.40					76	50	26	24	0		0.84
BB70	Alameda	Aug. 28	1995	1995-08	37	44.84	122	19.40					97	69	28	5	0		1.94
BB70	Alameda	Feb. 21	1996	1996-02	37	44.84	122	19.40					80	51	29	20	0	10	0.3
BB70	Alameda	Aug. 1	1996	1996-07	37	44.84	122	19.40					85	53	32	15	0	10	0.5
BB70	Alameda	Feb. 3	1997	1997-01	37	44.84	122	19.40					90	59	31	10	0	9	0.3
BB70	Alameda	Aug. 12	1997	1997-08	37	44.84	122	19.40					64	45	20	36	0	10	0.2
BB70	Alameda	Feb. 10	1998	1998-02	37	44.84	122	19.40					74	46	28	26	0	10	0.3
BB70	Alameda	Aug. 3	1998	1998-07	37	44.84	122	19.40					70	50	21	30	0	10	0.3
BB70	Alameda	Feb. 17	1999	1999-02	37	44.84	122	19.40					72	42	30	28	0	10	ND
BB70	Alameda	Jul. 26	1999	1999-07	37	44.84	122	19.40					69	46	23	31	0	11	0.6
BB70	Alameda	Jul. 24	2000	2000-07	37	44.84	122	19.40					70	47	23	30	0	11	2
BC60	Red Rock	Feb. 11	1994	1994-02	37	55.00	122	25.97	29.2	11.8	8		5	3	2	89	6	9.5	
BC60	Red Rock	Aug. 26	1994	1994-08	37	55.00	122	25.97	31.94	16.8	6		2	1	1	85	13	10.3	
BC60	Red Rock	Feb. 17	1995	1995-02	37	55.00	122	25.97					7	5	2	89	4		0.55
BC60	Red Rock	Aug. 25	1995	1995-08	37	55.00	122	25.97					5	4	1	85	10		0.26
BC60	Red Rock	Feb. 20	1996	1996-02	37	55.00	122	25.97					5	3	2	90	6	9	0.1
BC60	Red Rock	Aug. 2	1996	1996-07	37	55.00	122	25.97					4	3	1	93	2	11	2.5
BC60	Red Rock	Aug. 11	1997	1997-08	37	55.00	122	25.97					41	31	9	59	1	11	0.3

BC60	Red Rock	Feb. 9	1998	1998-02	37	55.00	122	25.97				44	26	17	56	0	11	0.1
BC60	Red Rock	Feb. 16	1999	1999-02	37	55.00	122	25.97				30	20	9	69	1	11	ND
BC60	Red Rock	Feb. 3	1997	1997-01	37	55.00	122	25.97				13	9	4	80	7	12	0.7
BC60	Red Rock	Jul. 31	1998	1998-07	37	55.00	122	25.97				6	4	2	94	0	11	0.2
BC60	Red Rock	Jul. 23	1999	1999-07	37	55.00	122	25.97				9	6	3	91	0	10	2.1
BC60	Red Rock	Jul. 24	2000	2000-07	37	55.00	122	25.97				7	4	3	87	6	10	0.4
BB30	Oyster Point	Mar. 11	1993	1993-03	37	40.21	122	19.77	16.43	11.5		73	50	23	27	0	9	
BB30	Oyster Point	Sept. 22	1993	1993-09	37	40.21	122	19.77	29.31	17.9		61	43	18	27	12	9	
BB30	Oyster Point	Feb, 15	1994	1994-02	37	40.21	122	19.77	27.88	11.3	8	43	29	14	53	3	7.3	
BB30	Oyster Point	Aug. 29	1994	1994-08	37	40.21	122	19.77	31.73	19.8	6	61	41	20	36	2	7.3	
BB30	Oyster Point	Feb. 20	1995	1995-02	37	40.21	122	19.77				67	46	21	27	6		3.01
BB30	Oyster Point	Aug. 30	1995	1995-08	37	40.21	122	19.77				68	48	20	30	2		1.35
BB30	Oyster Point	Feb. 21	1996	1996-02	37	40.21	122	19.77				77	49	28	20	3	8	0.4
BB30	Oyster Point	Aug. 1	1996	1996-07	37	40.21	122	19.77				85	57	28	14	0	9	0.7
BB30	Oyster Point	Feb. 5	1997	1997-01	37	40.21	122	19.77				77	49	29	21	2	10	0
BB30	Oyster Point	Aug. 12	1997	1997-08	37	40.21	122	19.77				59	41	18	39	2	9	0.2
BB30	Oyster Point	Feb. 10	1998	1998-02	37	40.21	122	19.77				75	49	25	25	0	9	0.1
BB30	Oyster Point	Feb. 17	1999	1999-02	37	40.21	122	19.77				57	36	21	38	5	9	NA
BB30	Oyster Point	Aug. 4	1998	1998-07	37	40.21	122	19.77				50	35	15	40	10	9	0.6
BB30	Oyster Point	Jul. 27	1999	1999-07	37	40.21	122	19.77				45	29	16	48	7	9	1.2
BB30	Oyster Point	Jul. 25	2000	2000-07	37	40.21	122	19.77				56	38	18	41	3	9	1.2
BB15	San Bruno Shoal	Feb, 15	1994	1994-02	37	37.00	122	17.00	27.7	11.2	8	69	48	21	27	4	11	
BB15	San Bruno Shoal	Aug. 30	1994	1994-08	37	37.00	122	17.00	31.64	20.3	6	57	37	20	40	3	11.5	
BB15	San Bruno Shoal	Feb. 21	1995	1995-02	37	37.00	122	17.00				82	54	28	16	2		2.41
BB15	San Bruno Shoal	Aug. 29	1995	1995-08	37	37.00	122	17.00				66	45	21	30	4		0.49
BB15	San Bruno Shoal	Feb. 21	1996	1996-02	37	37.00	122	17.00				89	57	32	11	0	12	1.1
BB15	San Bruno Shoal	Aug. 1	1996	1996-07	37	37.00	122	17.00				54	36	18	42	4	12	2.2
BB15	San Bruno Shoal	Feb. 4	1997	1997-01	37	37.00	122	17.00				58	40	18	27	15	14	0.3
BB15	San Bruno Shoal	Aug. 12	1997	1997-08	37	37.00	122	17.00				48	35	13	46	6	12	0.3
BB15	San Bruno Shoal	Feb. 10	1998	1998-02	37	37.00	122	17.00				92	59	33	8	0	12	1.4
BB15	San Bruno Shoal	Aug. 4	1998	1998-07	37	37.00	122	17.00				96	74	22	4	0	12	5.1
BB15	San Bruno Shoal	Feb. 17	1999	1999-02	37	37.00	122	17.00				50	33	17	50	0	12	ND
BB15	San Bruno Shoal	Jul. 27	1999	1999-07	37	37.00	122	17.00				93	62	31	4	3	11	2.5
BB15	San Bruno Shoal	Jul. 25	2000	2000-07	37	37.00	122	17.00				99	67	32	1	0	12	9
BA30	Dumbarton Bridge	Mar. 12	1993	1993-03	37	30.87	122	8.08	13.77	11.2		95	67	28	5	0	7	
BA30	Dumbarton Bridge	Sept. 23	1993	1993-09	37	30.87	122	8.08	28.66	18.3		95	70	25	3	2	7	
BA30	Dumbarton Bridge	Feb. 16	1994	1994-02	37	30.87	122	8.08	27.07	11.3	8	64	43	21	29	8	8.3	
BA30	Dumbarton Bridge	Feb. 22	1996	1996-02	37	30.87	122	8.08				93	61	32	6	0	7	0.2
BA30	Dumbarton Bridge	Jul. 31	1996	1996-07	37	30.87	122	8.08				88	56	32	6	6	7	0.6
BA30	Dumbarton Bridge	Aug. 30	1994	1994-08	37	30.87	122	8.08	31.49	21.2	6	97	66	31	3	0	6.5	
BA30	Dumbarton Bridge	Aug. 30	1995	1995-08	37	30.87	122	8.08				96	60	36	4	0		5.01
BA30	Dumbarton Bridge	Feb. 21	1995	1995-02	37	30.87	122	8.08				95	68	27	5	0		0.34
BA30	Dumbarton Bridge	Feb. 4	1997	1997-01	37	30.87	122	8.08				91	62	29	8	1	8	0
BA30	Dumbarton Bridge	Aug. 13	1997	1997-08	37	30.87	122	8.08				95	55	40	4	1	7	3.3
BA30	Dumbarton Bridge	Feb. 10	1998	1998-02	37	30.87	122	8.08				97	61	35	3	0	7	0
BA30	Dumbarton Bridge	Aug. 4	1998	1998-07	37	30.87	122	8.08				62	42	20	35	3	7	1.7
BA30	Dumbarton Bridge	Feb. 17	1999	1999-02	37	30.87	122	8.08				87	56	30	12	2	7	NA
BA30	Dumbarton Bridge	Jul. 27	1999	1999-07	37	30.87	122	8.08				96	62	34	4	0	5	4
BA30	Dumbarton Bridge	Jul. 25	2000	2000-07	37	30.87	122	8.08				99	65	34	1	0	6	10
BA21	South Bay	Mar. 12	1993	1993-03	37	29.64	122	5.25	6.78	12.5		98	77	21	2	0	5.5	
BA21	South Bay	Sept. 23	1993	1993-09	37	29.64	122	5.25	28.5	18.6		94	70	24	4	2	5.5	
BA21	South Bay	Feb. 16	1994	1994-02	37	29.64	122	5.25	25.2	11.7	8	81	59	22	8	12	3.8	
BA21	South Bay	Aug. 30	1994	1994-08	37	29.64	122	5.25	30.59	21.7	6	92	71	21	5	3	2.8	
BA21	South Bay	Feb. 21	1995	1995-02	37	29.64	122	5.25				97	72	25	3	0		4.36
BA21	South Bay	Aug. 29	1995	1995-08	37	29.64	122	5.25				98	67	31	2	0		5.22
BA21	South Bay	Feb. 21	1996	1996-02	37	29.64	122	5.25				99	73	26	2	0	4	1
BA21	South Bay	Aug. 1	1996	1996-07	37	29.64	122	5.25				97	69	28	1	2	5.5	11.6
BA21	South Bay	Feb. 4	1997	1997-01	37	29.64	122	5.25				97	68	29	1	1	5	0.1
BA21	South Bay	Aug. 12	1997	1997-08	37	29.64	122	5.25				91	59	32	7	2	5.5	1.7
BA21	South Bay	Feb. 10	1998	1998-02	37	29.64	122	5.25				97	71	26	3	0	6	0.4
BA21	South Bay	Aug. 4	1998	1998-07	37	29.64	122	5.25				97	66	31	3	0	6	0.5
BA21	South Bay	Feb. 17	1999	1999-02	37	29.64	122	5.25				96	61	35	2	2	6	ND
BA21	South Bay	Jul. 27	1999	1999-07	37	29.64	122	5.25				98	65	34	2	0	5	7
BA21	South Bay	Jul. 25	2000	2000-07	37	29.64	122	5.25				97	70	27	3	1	5	8
C-1-3	Sunnyvale	Feb. 16	1994	1994-02	37	26.13	122	0.67	7.72	12.5	7	87 NA	NA		13	0	1	
C-1-3	Sunnyvale	Aug. 31	1994	1994-08	37	26.13	122	0.67	14.49	21.7	4	44	29	15	56	0	1	
C-1-3	Sunnyvale	Feb. 22	1995	1995-02	37	26.13	122	0.67				12	8	4	88	0		4.07
C-1-3	Sunnyvale	Aug. 29	1995	1995-08	37	26.13	122	0.67				48	33	15	53	0		2.12

C-1-3	Sunnyvale	Feb. 21	1996	1996-02	37	26.13	122	0.67				50	31	19	51	0	3	1.8
C-1-3	Sunnyvale	Jul. 31	1996	1996-07	37	26.13	122	0.67				53	30	23	46	0	2.5	4
C-1-3	Sunnyvale	Feb. 5	1997	1997-01	37	26.13	122	0.67				28	20	9	72	0	4	0.1
C-1-3	Sunnyvale	Aug. 13	1997	1997-08	37	26.13	122	0.67				96	44	52	4	0	2.5	4.1
C-1-3	Sunnyvale	Feb. 11	1998	1998-02	37	26.13	122	0.67				67	39	28	33	0	3	1.5
C-1-3	Sunnyvale	Aug. 5	1998	1998-07	37	26.13	122	0.67				66	48	18	34	0	3	11.8
C-1-3	Sunnyvale	Feb. 18	1999	1999-02	37	26.13	122	0.67				26	16	9	73	2	3	NA
C-1-3	Sunnyvale	Jul. 28	1999	1999-07	37	26.13	122	0.67				19	11	8	81	0	2	2.7
C-1-3	Sunnyvale	Jul. 26	2000	2000-07	37	26.13	122	0.67				93	72	21	7	0	3	4
C-3-0	San Jose	Feb. 16	1994	1994-02	37	27.72	121	58.53	16.6	13	7	7	4	3	90	3	1.8	
C-3-0	San Jose	Aug. 31	1994	1994-08	37	27.72	121	58.53	25.38	22.3	6	40	26	14	60	0	1.5	
C-3-0	San Jose	Feb. 22	1995	1995-02	37	27.72	121	58.53				18	13	5	76	5		0.9
C-3-0	San Jose	Aug. 29	1995	1995-08	37	27.72	121	58.53				72	52	20	28	0		2.78
C-3-0	San Jose	Feb. 21	1996	1996-02	37	27.72	121	58.53				46	29	17	54	0	3	0.1
C-3-0	San Jose	Feb. 5	1997	1997-01	37	27.72	121	58.53				25	17	8	75	0	5	0
C-3-0	San Jose	Aug. 13	1997	1997-08	37	27.72	121	58.53				76	25	51	24	0	3	7.7
C-3-0	San Jose	Feb. 11	1998	1998-02	37	27.72	121	58.53				66	44	22	34	0	3	0.1
C-3-0	San Jose	Aug. 5	1998	1998-07	37	27.72	121	58.53				96	65	30	4	0	3	5.2
C-3-0	San Jose	Feb. 18	1999	1999-02	37	27.72	121	58.53				30	20	10	68	2	3	ND
C-3-0	San Jose	Jul. 28	1999	1999-07	37	27.72	121	58.53				60	42	18	40	0	2	3
C-3-0	San Jose	Jul. 26	2000	2000-07	37	27.72	121	58.53				38	22	16	57	5	3	1
C-3-0	San Jose	Jul. 31	1996	1996-07	37	27.72	121	58.53				85	55	30	15	0	3	6.1
BF40	Honker Bay	Feb. 10	1994	1994-02	38	4.00	121	56.00	2.57	10.4	10	100	72	28	1	0	1.8	
BF40	Honker Bay	Aug. 25	1994	1994-08	38	4.00	121	56.00	7.46	21.6	7	97	66	31	3	0	1.5	
BF40	Honker Bay	Feb. 16	1994	1995-02	38	4.00	121	56.00				97	62	35	3	0		1.95
BF40	Honker Bay	Aug. 24	1995	1995-08	38	4.00	121	56.00				92	61	31	7	0		1.11
BF40	Honker Bay	Feb. 15	1996	1996-02	38	4.00	121	56.00				95	51	44	4	0	3	1.3
BF40	Honker Bay	Aug. 6	1996	1996-07	38	4.00	121	56.00				90	51	39	10	0	3	1
BF40	Honker Bay	Jan. 30	1997	1997-01	38	4.00	121	56.00				97	56	41	3	0	2	0.3
BF40	Honker Bay	Aug. 7	1997	1997-08	38	4.00	121	56.00				93	56	37	7	0	3	2.6
BF40	Honker Bay	Feb. 5	1998	1998-02	38	4.00	121	56.00				98	57	41	2	0	3	0.1
BF40	Honker Bay	Jul. 30	1998	1998-07	38	4.00	121	56.00				97	61	36	3	0	3	0.4
BF40	Honker Bay	Feb. 11	1999	1999-02	38	4.00	121	56.00				92	48	44	8	0	3	NA
BF40	Honker Bay	Jul. 22	1999	1999-07	38	4.00	121	56.00				89	48	41	11	0	2	1.6
BF40	Honker Bay	Jul. 20	2000	2000-07	38	4.00	121	56.00				94	59	35	5	0	2	2.4
BC32	Richardson Bay	Mar. 11	1993	1993-03	37	51.82	122	28.72	16.48	13.6		81	44	37	18	1	1	
BC32	Richardson Bay	Sept. 22	1993	1993-09	37	51.82	122	28.72	30.38	15.2		72	35	37	28	0	1	
BC32	Richardson Bay	Feb. 14	1994	1994-02	37	51.82	122	28.72	29.47	11.6	8	75	34	41	24	0	2	
BC32	Richardson Bay	Aug. 29	1994	1994-08	37	51.82	122	28.72	31.88	17.1	6	75	34	41	25	0	1.8	
BC32	Richardson Bay	Feb. 20	1995	1995-02	37	51.82	122	28.72				73	33	40	27	0		0.46
BC32	Richardson Bay	Aug. 28	1995	1995-08	37	51.82	122	28.72				80	41	39	20	0		0.66
BC32	Richardson Bay	Feb. 20	1996	1996-02	37	51.82	122	28.72				81	39	42	19	0	3	0.1
BC32	Richardson Bay	Aug. 11	1997	1997-08	37	51.82	122	28.72				80	49	31	20	0	1	0.5
BC32	Richardson Bay	Aug. 2	1996	1996-07	37	51.82	122	28.72				78	35	43	21	0	1	3.2
BC32	Richardson Bay	Feb. 3	1997	1997-01	37	51.82	122	28.72				91	54	36	9	0	3	2.3
BC32	Richardson Bay	Feb. 9	1998	1998-02	37	51.82	122	28.72				84	41	43	16	0	1	0.2
BC32	Richardson Bay	Aug. 3	1998	1998-07	37	51.82	122	28.72				83	47	37	17	0	1	0.1
BC32	Richardson Bay	Feb. 16	1999	1999-02	37	51.82	122	28.72				83	45	39	17	0	1	NA
BC32	Richardson Bay	Jul. 26	1999	1999-07	37	51.82	122	28.72				84	49	36	16	0	3	0.7
BC32	Richardson Bay	Jul. 24	2000	2000-07	37	51.82	122	28.72				87	39	48	13	0	3	0.4
BW10	Standish Dam	Mar. 8	1996	1996-02								51	17	34	49	0	NA	NA
BW10	Standish Dam	Aug. 12	1996	1996-07								89	58	31	11	0	NA	NA
BW10	Standish Dam	Feb. 7	1997	1997-01								74	25	49	26	0	0	0.2
BW10	Standish Dam	Aug. 6	1997	1997-08								87	58	29	13	0	0	3.6
BW10	Standish Dam	Feb. 4	1998	1998-02								56	22	34	44	0	0	2.4
BW10	Standish Dam	Aug. 6	1998	1998-07								87	50	37	13	0	0	2.2
BW10	Standish Dam	Feb. 22	1999	1999-02								91	66	26	8	1	0	NA
BW10	Standish Dam	Jul. 29	1999	1999-07								95	69	26	5	0	0	0.7
BW10	Standish Dam	Jul. 11	2000	2000-07								97	69	28	4	0	0	0.9
BA10	Coyote Creek	Feb. 22	1995	1995-02	37	28.20	122	3.80				59	44	15	37	4		1.05
BA10	Coyote Creek	Aug. 30	1995	1995-08	37	28.20	122	3.80				96	73	23	3	1		0.42
BA10	Coyote Creek	Feb. 22	1996	1996-02	37	28.20	122	3.80				88	51	37	9	3	4	0.2
BA10	Coyote Creek	Jul. 31	1996	1996-07	37	28.20	122	3.80				40	28	12	46	14	5	0.9
BA10	Coyote Creek	Feb. 4	1997	1997-01	37	28.20	122	3.80				99	76	23	1	0	7	0.1
BA10	Coyote Creek	Aug. 13	1997	1997-08	37	28.20	122	3.80				85	33	52	10	4	5	5.6
BA10	Coyote Creek	Feb. 11	1998	1998-02	37	28.20	122	3.80				98	61	37	2	0	5	0.3

BA10	Coyote Creek	Aug. 4	1998	1998-07	37	28.20	122	3.80			74	51	23	7	19	5	0.9
BA10	Coyote Creek	Feb. 17	1999	1999-02	37	28.20	122	3.80			36	24	12	49	15	5	ND
BA10	Coyote Creek	Jul. 28	1999	1999-07	37	28.20	122	3.80			45	30	14	40	15	4	2.7
BA10	Coyote Creek	Jul. 25	2000	2000-07	37	28.20	122	3.80			92	67	25	6	1	5	8
BD15	Petaluma River	Aug. 25	1995	1995-08	37	28.20	122	3.80			89	64	25	8	3		2.68
BD15	Petaluma River	Feb. 17	1995	1995-02	38	6.66	122	29.00			97	70	27	3	0		3.69
BD15	Petaluma River	Feb. 16	1996	1996-02	38	6.66	122	29.00			97	62	35	3	0	3	1.3
BD15	Petaluma River	Aug. 5	1996	1996-07	38	6.66	122	29.00			99	66	33	1	0	4	0.2
BD15	Petaluma River	Jan. 31	1997	1997-01	38	6.66	122	29.00			100	66	34	0	0	4	1.8
BD15	Petaluma River	Aug. 8	1997	1997-08	38	6.66	122	29.00			96	66	29	4	0	4	2
BD15	Petaluma River	Feb. 6	1998	1998-02	38	6.66	122	29.00			96	68	28	4	0	4	0.6
BD15	Petaluma River	Jul. 31	1998	1998-07	38	6.66	122	29.00			95	61	34	5	0	4	0.8
BD15	Petaluma River	Feb. 12	1999	1999-02	38	6.66	122	29.00			91	65	25	8	1	4	NA
BD15	Petaluma River	Jul. 23	1999	1999-07	38	6.66	122	29.00			98	59	40	2	0	3	2
BD15	Petaluma River	Feb. 10	2000	2000-02	38	6.66	122	29.00			98	65	33	2	0	4	2.3
BD15	Petaluma River	Jul. 21	2000	2000-07	38	6.66	122	29.00			98	55	43	2	0	4	3
BW15	Guadalupe River	Feb. 7	1997	1997-01							90	65	24	10	0	0	0.3
BW15	Guadalupe River	Aug. 6	1997	1997-08							99	79	20	1	0	0	0.3
BW15	Guadalupe River	Feb. 4	1998	1998-02							99	78	21	1	0	0	1.8
BW15	Guadalupe River	Aug. 6	1998	1998-07							100	79	21	0	0	0	1
BW15	Guadalupe River	Feb. 9	1999	1999-02							100	81	19	0	0	0	NA
BW15	Guadalupe River	Jul. 29	1999	1999-07							100	82	18	0	0	0	1.4
BW15	Guadalupe River	Jul. 11	2000	2000-07							99	81	18	0	0	0	0.8

Data contributed by JC Oil Environmental Consulting

FN 1	Sacramento River	Aug.	1973	1973-08	38	3.05	121	52.85			11.78	20.29	67.93	0	13	
FN 2	Honker Bay	Aug.	1973	1973-08	38	4.10	121	56.05			4.81	20.54	74.64	0	3	
FN 3	Grizzly Bay	Aug.	1973	1973-08	38	7.85	122	0.65			32.79	62.21	0	0	2.5	
FN 4	Grizzly Bay	Aug.	1973	1973-08	38	7.05	122	3.25			21.54	65.84	12.61	0	3.2	
FN 5	Suisun Bay off Garnet Pt.	Aug.	1973	1973-08	38	5.85	122	5.90			31.16	49.2	19.64	0	7	
FN 6	Suisun Bay off Reserve Fleet	Aug.	1973	1973-08	38	4.05	122	8.85			3.26	3.8	92.93	0	10	
FN 7	Carquinez Strait	Aug.	1973	1973-08	38	2.00	122	15.90			3.11	5.39	91.5	0	14.5	
FN 8	Off Mare Island	Aug.	1973	1973-08	38	3.80	122	25.20			25.84	57.08	17.06	0	17	
FN 9	N. San Pablo Bay	Aug.	1973	1973-08	38	3.8	122	23.65			40.66	52.1	7.23	x	1.3	
FN 10	Mid San Pablo Bay	Aug.	1973	1973-08	38	5.6	122	22.25			44.96	55.04	0	0	2	
FN 11	Mid San Pablo Bay	Aug.	1973	1973-08	38	4.30	122	21.75			52.54	46.51	2	x	4	
FN 12	San Pablo Bay near channel	Aug.	1973	1973-08	38	2.85	122	21.10			15.75	49.78	34.46	0	11	
FN 13	Off Point Pinole	Aug.	1973	1973-08	38	2.25	122	20.75			33.68	55.42	10.88	x	5	
FN 14	Off Point Pinole	Aug.	1973	1973-08	38	1.40	122	20.40			42.02	57.97	0	0	1.6	
FN 15	San Pablo Strait	Aug.	1973	1973-08	38	1.05	122	24.90			39.35	60.64	0	0	1	
FN 16	Off Point San Pablo	Aug.	1973	1973-08	38	0.55	122	26.25			0.02	0.02	99.96	0	13	
FN 17	Off Tiburon Peninsula	Aug.	1973	1973-08	38	0.50	122	26.45			13.51	32.72	53.76	0	24	
FN 18	Off San Francisco Lightship	Aug.	1973	1973-08	37	58.50	122	41.50			0.04	0.03	95.62	1.3	12.5	
FN 19	Off Fourfathom Rank	Aug.	1973	1973-08	37	54.85	122	36.85			5.04	4.03	90.93	0	33	
FN 20	Ship Channel off Pt. Bonita	Aug.	1973	1973-08	37	46.00	122	32.10			0.02	0.02	99.96	0	12	
FN 21	Between Angel & Treasure Is.	Aug.	1973	1973-08	37	46.85	122	32.10			0.02	0.01	98.6	1.37	31	
FN 22	Berkeley Pier (outer)	Aug.	1973	1973-08	37	48.00	122	24.35			8.06	11.51	80.24	0.18	25	
FN 23	Berkeley Pier (inner)	Aug.	1973	1973-08	37	50.35	122	22.50			28	11.57	60.42	x	7	
FN 24	Off China Basin	Aug.	1973	1973-08	37	50.35	122	20..60			37.84	60.62	1.54	x	5	

Janet K. Thompson. Sediment Grain Size Distribution in San Francisco Bay, California, January/February and August 1973. U.S. Geological Survey. App. B

MIS-A P	Mare Island Strait ship channel	Mar.	1973	1973-03	38	5.38	122	15.33	14.2	8.6	48.3	48.9	2.8		30-36	
MIS-A 1	Mare Island Strait ship channel	Sept.	1973	1973-09	38	5.38	122	15.33	14.2	8.2	50.3	41.7	8		30-36	
MIS-A 2	Mare Island Strait ship channel	Dec.	1973	1973-12	38	5.38	122	15.33	14.2	9.6	6.3	90	3.7		30-36	
MIS-A 3	Mare Island Strait ship channel	Mar.	3/74	1974-03	38	5.38	122	15.33	14.2	7.1	60.8	36	3.2		30-36	
MIS-A 4	Mare Island Strait ship channel	June	6/74	1974-06	38	5.38	122	15.33	14.2	8.4	56.6	42.2	1.2		30-36	
MIS-B P	Mare Island Strait, eastern shore	Mar.	3/73	1973-03	38	5.42	122	15.28	14.1	9	50.7	46.3	3		20-36	
MIS-B 1	Mare Island Strait, eastern shore	Sept.	9/73	1973-09	38	5.42	122	15.28	14.1	7.2	58.2	38	3.8		20-36	
MIS-B 2	Mare Island Strait, eastern shore	Dec.	12/73	1973-12	38	5.42	122	15.28	14.1	9.8	4.8	90.1	5.1		20-36	
MIS-B 3	Mare Island Strait, eastern shore	Mar.	3/74	1974-03	38	5.42	122	15.28	14.1	10.1	55	38.4	5.8		20-36	
MIS-B 4	Mare Island Strait, eastern shore	June	6/74	1974-06	38	5.42	122	15.28	14.1	8.6	54	43	3		20-36	
CS-A P	Carquinez Strait disposal site	Mar.	3/73	1973-03	38	3.49	122	15.50	13.9	8	45	46.9	8.1		48-50	
CS-A 1	Carquinez Strait disposal site	Sept.	9/73	1973-09	38	3.49	122	15.50	13.9	7.4	48.8	32.5	18.7		48-50	

CS-A 2	Carquinez Strait disposal site	Dec.	12/73	1973-12	38	3.49	122	15.50	13.9	9.4	7.9	79.7	12.4	48-50
CS-A 3	Carquinez Strait disposal site	Mar.	3/74	1974-03	38	3.49	122	15.50	13.9	9.1	13.7	8.4	77.9	48-50
CS-A 4	Carquinez Strait disposal site	June	6/74	1974-06	38	3.49	122	15.50	13.9	8.2	40.6	25.3	34.1	48-50
CS-B P	Carquinez Strait disposal site	Mar.	3/73	1973-03	38	3.57	122	15.50	14	8.2	10.3	9.8	79.9	40-48
CS-B 1	Carquinez Strait disposal site	Sept.	9/73	1973-09	38	3.57	122	15.50	14	7.4	29	23.2	47.8	40-48
CS-B 2	Carquinez Strait disposal site	Sept.	12/73	1973-12	38	3.57	122	15.50	14	9.8	2.1	63.1	34.8	40-48
CS-B 3	Carquinez Strait disposal site	Mar.	3/74	1974-03	38	3.57	122	15.50	14	9	30.4	17.8	51.8	40-48
CS-B 4	Carquinez Strait disposal site	June	6/74	1974-06	38	3.57	122	15.50	14	8.4	29.5	18.3	52.2	40-48
ALC P	Alcatraz disposal site	Mar.	3/73	1973-03	37	40.27	122	25.55	12.1	7.4	4.7	6.5	88.8	58-67
ALC 1	Alcatraz disposal site	Sept.	9/73	1973-09	37	40.27	122	25.55	12.1	7.7	1.3	1.1	97.6	58-67
ALC 2	Alcatraz disposal site	Dec.	12/73	1973-12	37	40.27	122	25.55	12.1	8.6	3.7	81.4	14.9	58-67
ALC 3	Alcatraz disposal site	Mar.	3/74	1974-03	37	40.27	122	25.55	12.1	8.3	49.8	37	13.2	58-67
ALC 4	Alcatraz disposal site	June	6/74	1974-06	37	40.27	122	25.55	12.1	7.8	0.1	0.4	95	58-67
OIH P	Oakland Inner Harbor ship channel	Mar.	3/73	1973-03	37	20.46	122	19.04	13.8	7.2	4.3	23.4	72.3	30-38
OIH 1	Oakland Inner Harbor ship channel	Sept.	9/73	1973-09	37	20.46	122	19.04	13.8	6.9	25.2	19.7	55.1	30-38
OIH 2	Oakland Inner Harbor ship channel	Dec.	12/73	1973-12	37	20.46	122	19.04	13.8	7.8	1.4	28.7	69.9	30-38
OIH 3	Oakland Inner Harbor ship channel	Mar.	3/74	1974-03	37	20.46	122	19.04	13.8	8	20.5	15.4	64.1	30-38
OIH 4	Oakland Inner Harbor ship channel	June	6/74	1974-06	37	20.46	122	19.04	13.8	7.8	19.1	14.7	66.2	30-38
HP P	Hunters Point disposal site	Mar.	3/73	1973-03	37	44.15	122	20.3	13.4	7.4	20.1	71.4	8.5	45-58
HP 1	Hunters Point disposal site	Sept.	9/73	1973-09	37	44.15	122	20.3	13.4	7.1	43.3	28.4	28.3	45-58
HP 2	Hunters Point disposal site	Dec.	12/73	1973-12	37	44.15	122	20.3	13.4	8	4.4	64.7	30.9	45-58
HP 3	Hunters Point disposal site	Mar.	3/74	1974-03	37	44.15	122	20.3	13.4	8.4	43.9	32.7	23.4	45-58
HP 4	Hunters Point disposal site	June	6/74	1974-06	37	44.15	122	20.3	13.4	8	51.4	28.9	19.7	45-58
SB-A P	Southbay disposal site	Mar.	3/73	1973-03	37	34.05	122	12.33	14.6	8.8	52.5	43.8	3.7	40-42
SB-A 1	Southbay disposal site	Sept.	9/73	1973-09	37	34.05	122	12.33	14.6	6.8	62.1	29.6	8.3	40-42
SB-A 2	Southbay disposal site	Dec.	12/73	1973-12	37	34.05	122	12.33	14.6	8.4	0.8	33.1	66.1	40-42
SB-A 3	Southbay disposal site	Mar.	3/74	1974-03	37	34.05	122	12.33	14.6	9.2	53.8	37.9	8.3	40-42
SB-A 4	Southbay disposal site	June	6/74	1974-06	37	34.05	122	12.33	14.6	7.5	36.8	30.3	32.9	40-42
SB-B P	Southbay disposal site	Mar.	3/73	1973-03	37	34.47	122	13.45	14.6	9	3.9	93.7	2.4	30-38
SB-B 1	Southbay disposal site	Sept.	9/73	1973-09	37	34.47	122	13.45	14.6	6.6	53.8	41.4	4.8	30-38
SB-B 2	Southbay disposal site	Dec.	12/73	1973-12	37	34.47	122	13.45	14.6	9	2.8	87.2	10	30-38
SB-B 3	Southbay disposal site	Mar.	3/74	1974-03	37	34.47	122	13.45	14.6	8.9	54.7	39.6	5.7	30-38
SB-B 4	Southbay disposal site	June	6/74	1974-06	37	34.47	122	13.45	14.6	7.4	29.1	75.2	2.9	30-38
RCH-A P	Redwood City Harbor entrance	Mar.	3/73	1973-03	37	33.03	122	11.4	14.9	9	52.8	40.6	6.6	24.47
RCH-A 1	Redwood City Harbor entrance	Sept.	9/73	1973-09	37	33.03	122	11.4	14.9	6.8	58.1	30.8	11.1	24.47
RCH-A 2	Redwood City Harbor entrance	Sept.	12/73	1973-12	37	33.03	122	11.4	14.9	8.2	3.7	78.3	8	24.47
RCH-A 3	Redwood City Harbor entrance	Mar.	3/74	1974-03	37	33.03	122	11.4	14.9	9	55.9	34.8	9.3	24.47
RCH-A 4	Redwood City Harbor entrance	June	6/74	1974-06	37	33.03	122	11.4	14.9	7.1	43.7	26.3	30	24.47
RCH-B P	Redwood City Harbor entrance	Mar.	3/73	1973-03	37	32.27	122	11.32	15.1	8.6	44.4	50.4	5.2	24-36
RCH-B 1	Redwood City Harbor entrance	Sept.	9/73	1973-09	37	32.27	122	11.32	15.1	6.7	57.3	36.7	6	24-36
RCH-B 2	Redwood City Harbor entrance	Dec.	12/73	1973-12	37	32.27	122	11.32	15.1	8.2	5.8	91.2	3	24-36
RCH-B 3	Redwood City Harbor entrance	Mar.	3/74	1974-03	37	32.27	122	11.32	15.1	8.7	60.3	36	3.7	24-36
RCH-B 4	Redwood City Harbor entrance	June	6/74	1974-06	37	32.27	122	11.32	15.1	7.2	59.7	37.5	2.8	24-36

From San Francisco Bay Dredge Disposal Study, Appendix D: Biological Community, U.S. Army Corps of Engineers

H-1		Mar. 20	2002	2002-03	37	49.695	122	26.947				0.28	99.72	72
H-2		Mar. 20	2002	2002-03	37	49.406	122	26.555				0.08	99.92	77
H-3		Mar. 20	2002	2002-03	37	49.526	122	26.303				0.07	99.93	71
H-4		Mar. 20	2002	2002-03	37	49.679	122	26.188				0.04	99.96	72
H-5		Mar. 20	2002	2002-03	37	49.649	122	25.922				0.02	99.98	67
H-6		Mar. 20	2002	2002-03	37	49.760	122	25.852				0.11	99.89	75
H-7		Mar. 20	2002	2002-03	37	49.811	122	25.637				0.1	99.91	92
H-8		Mar. 20	2002	2002-03	37	49.435	122	26.050				0.08	99.92	61
H-9		Mar. 20	2002	2002-03	37	49.371	122	25.866				0.23	99.77	65
H-10		Mar. 20	2002	2002-03	37	49.409	122	25.074				69.9	30.1	116

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H1-1	Dec.12-14	2001	2001-12	37 51.089	122	25.315	2.42	9.36	46	
H1-2	Dec.12-14	2001	2001-12	37 50.961	122	25.302	12.65	45.61	103	
H1-3	Dec.12-14	2001	2001-12	37 50.819	122	25.283	10.4	45.07	144	
H1-4	Dec.12-14	2001	2001-12	37 50.701	122	25.255	4.71	18.3	150	
H1-5	Dec.12-14	2001	2001-12	37 50.687	122	25.418	20.55	68.53	131	
H1-6	Dec.12-14	2001	2001-12	37 50.798	122	25.46	5	17.13	116	
H1-7	Dec.12-14	2001	2001-12	37 50.953	122	25.494	0	0	68	
H1-8	Dec.12-14	2001	2001-12	37 51.098	122	25.547	0.77	2.69	58	some shell hash
H1-9	Dec.12-14	2001	2001-12	37 51.094	122	25.757	4.81	18.98	65	some shell hash
H1-10	Dec.12-14	2001	2001-12	37 50.928	122	25.711	0.68	2.88	68	
H1-11	Dec.12-14	2001	2001-12	37 50.778	122	25.64	1.82	6.31	91	
H1-12	Dec.12-14	2001	2001-12	37 50.647	122	25.602	1.78	7.96	105	
H1-13	Dec.12-14	2001	2001-12	37 50.608	122	25.773	1.97	7.82	100	
H1-14	Dec.12-14	2001	2001-12	37 50.735	122	25.827	0.75	2.74	82	
H1-15	Dec.12-14	2001	2001-12	37 50.891	122	26.952	0.29	1.18	64	
H1-16	Dec.12-14	2001	2001-12	27 51.083	122	26.002	1.41	5.18	67	
H2-1	Dec.12-14	2001	2001-12	37 51.814	122	26.87	0	4.98	122	
H2-2	Dec.12-14	2001	2001-12	37 51.683	122	26.933	1.65	0	133	
H2-3	Dec.12-14	2001	2001-12	37 51.532	122	26.992	0.91	0	67	
H2-4	Dec.12-14	2001	2001-12	37 51.443	122	27.285	1.47	3.89	90	
H2-5	Dec.12-14	2001	2001-12	37 51.631	122	27.162	0.19	31.36	106	
H2-6	Dec.12-14	2001	2001-12	37 51.782	122	27.083	0.22	22.83	98	
H2-7	Dec.12-14	2001	2001-12	37 51.966	122	26.998	0.87	0	74	
H3-1	Dec.12-14	2001	2001-12	37 49.806	122	26.149	0.06	0.89	72	
H3-2	Dec.12-14	2001	2001-12	37 49.797	122	26.375	0.26	0.72	65	
H3-3-1	Dec.12-14	2001	2001-12	37 50.061	122	26.379	0.68	.	61	failed attempt*
H3-3-2	Dec.12-14	2001	2001-12	37 50.061	122	26.388	0	.	61	failed attempt*
H3-3-3	Dec.12-14	2001	2001-12	37 50.079	122	26.379	3.2	.	54	failed attempt*
H3-3-4	Dec.12-14	2001	2001-12	37 50.084	122	26.386	0	.	59	failed attempt*
H3-4	Dec.12-14	2001	2001-12	37 20.286	122	26.364	0	1.42	95	
H3-5	Dec.12-14	2001	2001-12	37 50.449	122	26.377	2.92	0	85	
H3-6	Dec.12-14	2001	2001-12	37 50.273	122	26.645	24.16	5.68	85	
H3-7	Dec.12-14	2001	2001-12	37 50.065	122	26.636	17.66	0.21	103	

H3-8	Dec.12-14	2001	2001-12	37 49.808	122	26.638	0	1.77	94	
H3-9	Dec.12-14	2001	2001-12	37 49.810	122	26.868		0	97	
H3-10	Dec.12-14	2001	2001-12	37 50.062	122	26.846		0	91	
H3-11	Dec.12-14	2001	2001-12	37 50.270	122	26.86		0	92	some shell hash
H3-12	Dec.12-14	2001	2001-12	37 50.259	122	27.091		0	80	
H3-13	Dec.12-14	2001	2001-12	37 50.056	122	27.101		0	88	
H3-14	Dec.12-14	2001	2001-12	37 49.797	122	27.123		0	78	
H3-15	Dec.12-14	2001	2001-12	37 49.809	122	27.348		1.31	110	
H3-16	Dec.12-14	2001	2001-12	37 50.058	122	27.346		1.99	112	
H3-17	Dec.12-14	2001	2001-12	37 50.266	122	27 348		0.24	90	
H3-18	Dec.12-14	2001	2001-12	37 50.255	122	27.574		0	92	
H3-19	Dec.12-14	2001	2001-12	37 50.059	122	27.587		0.28	113	
H3-20	Dec.12-14	2001	2001-12	37 49.815	122	27.584		0.92	145	
H3-21	Dec.12-14	2001	2001-12	37 49.81	122	27.782		0.08	158	
H3-22	Dec.12-14	2001	2001-12	37 50.049	122	27.808		0.34	143	
H3-23	Dec.12-14	2001	2001-12	37 50.255	122	27.802		8	95	
H3-24	Dec.12-14	2001	2001-12	37 50.442	122	27.802		4.99	114	
H3-25	Dec.12-14	2001	2001-12	37 50.702	122	27.823		0	83	
H3-26	Dec.12-14	2001	2001-12	37 20.646	122	28.031		5.74	89	
H3-27	Dec.12-14	2001	2001-12	37 50.421	122	28.016		2.14	123	
H3-28	Dec.12-14	2001	2001-12	37 20.252	122	28.004		1.01	154	
H3-29	Dec.12-14	2001	2001-12	37 20.048	122	28.008		0.92	191	
H3-30	Dec.12-14	2001	2001-12	37 49.805	122	28.005		0	182	

No sample collected at site H3-3, drag sampler snagged on attempts 1 and 2. Used sonar sampler on attempts 3 and 4, only able to collect kelp, algae, and bryozoans, indicative of a rocky bottom.

APPENDIX E

Results of MEC (1993) Water Quality Sampling
Within and Outside of Sand Mining Overflow Plumes in Central Bay

Special studies for sand mining: discharges of the Tidewater Sand and Gravel Company.

Table E-1. Summary of results for bioassay effluent tests for *Crassostrea gigas* (bivalve larvae).

Sample Collection June 30 - July 1, 1993 (Survey 2) / Testing July 1 - 3, 1993

Concentration (%)	Mean Total Larvae/mL	% Treatment Mortality	LCp (%)	% Abnormal	ICp (%)	NOEC (%)	TUc
Control	30.6	NA		2.0			
PS Unfiltered							
6.25	19.1*	37.6	LC50 59.9 (48.0 - 76.4)	18.8*	IC50 >100	< 6.25	> 16.0
12.5	21.7*	29.1	LC40 39.9 (31.7 - 49.2)	10.9	IC40 >100		
25	23.1*	24.5	LC25 < 6.25	17.8*	IC25 >100		
50	16.1*	47.4	LC15 < 6.25	8.1	IC15 >100		
100	11.8*	61.4	LC10 < 6.25	14.3	IC10 < 6.25		

Concentration (%)	Mean Total Larvae/mL	% Treatment Mortality	LCp (%)	% Abnormal	ICp (%)	NOEC (%)	TUc
PS Filtered							
6.25	16.7*	45.4	LC50 >100	2.8	IC50 >100	< 6.25	> 16.0
12.5	20.5*	33.0	LC40 >100	1.6	IC40 >100		
25	22.7*	25.8	LC25 < 6.25	0.9	IC25 >100		
50	19.9*	35.0	LC15 < 6.25	3.2	IC15 >100		
100	19.7*	35.6	LC10 < 6.25	3.7	IC10 >100		

Concentration (%)	Mean Total Larvae/mL	% Treatment Mortality	LCp (%)	% Abnormal	ICp (%)	NOEC (%)	TUc
PK Unfiltered							
6.25	24.0*	21.6	LC50 33.8 (24.9 - 48.9)	7.3*	IC50 >100	< 6.25	>16.0
12.5	17.7*	42.2	LC40 16.9 (11.3 - 23.1)	7.6*	IC40 >100		
25	15.8*	48.4	LC25 < 6.25	8.8*	IC25 >100		
50	14.1*	53.9	LC15 < 6.25	9.8*	IC15 >100		
100	11.0*	64.1	LC10 < 6.25	9.9*	IC10 >100		

Concentration (%)	Mean Total Larvae/mL	% Treatment Mortality	LCp (%)	% Abnormal	ICp (%)	NOEC (%)	TUc
PK Filtered							
6.25	19.9 *	35.0	LC50 >100	5.0 *	IC50 >100	< 6.25	>16.0
12.5	21.3 *	30.4	LC40 >100	3.1	IC40 >100		
25	20.6 *	32.7	LC25 < 6.25	4.8 *	IC25 >100		
50	20.5 *	33.0	LC15 < 6.25	16.0 *	IC15 >100		
100	25.8 *	15.7	LC10 < 6.25	15.4 *	IC10 41.0 (37.0 - 66.2)		

PS: Presidio Shoal
PK: Point Knox Shoal
*: Statistically significant.
LC/ICp: Lethal/Inhibition Concentration for p% of the organisms.
NOEC: No Observable Effect Concentration.
TUc: 100%/LC-IC25.
( ): 95% Confidence Limits.

Table E-1. Continued

Sample Collection August 19 - 20, 1993 (Survey 3) / Testing August 20 - 22, 1993

Concentration (%)	Mean Total Larvae/mL	% Treatment Mortality	LCp (%)	% Abnormal	ICp (%)	NOEC-a (%)	TUc
Control	18.3	NA		5.0			
PS Unfiltered							
6.25	20.0	0.0	**LC50** >100	5.4	**IC50** >100	25/100	<1.0
12.5	19.7	0.0	**LC40** >100	5.4	**IC40** >100		
25	20.6	0.0	**LC25** >100	6.0	**IC25** >100		
50	19.5	0.0	**LC15** >100	9.9*	**IC15** >100		
100	16.9	7.7	**LC10** 84.6	7.6	**IC10** >100		

Concentration (%)	Mean Total Larvae/mL	% Treatment Mortality	LCp (%)	% Abnormal	ICp (%)	NOEC (%)	TUc
PS Filtered							
6.25	20.3	0.0	**LC50** >100	4.1	**IC50** >100	100	<1.0
12.5	18.5	0.0	**LC40** >100	1.3	**IC40** >100		
25	18.9	0.0	**LC25** >100	1.0	**IC25** >100		
50	20.5	0.0	**LC15** >100	3.4	**IC15** >100		
100	20.1	0.0	**LC10** >100	2.0	**IC10** >100		

Concentration (%)	Mean Total Larvae/mL	% Treatment Mortality	LCp (%)	% Abnormal	ICp (%)	NOEC (%)	TUc
PK Unfiltered							
6.25	26.5	0.0	**LC50** >100	2.5	**IC50** >100	100	<1.0
12.5	30.1	0.0	**LC40** >100	4.2	**IC40** >100		
25	19.0	0.0	**LC25** >100	1.8	**IC25** >100		
50	21.6	0.0	**LC15** 24.9	2.0	**IC15** >100		
100	22.9	0.0	**LC10** 20.8	4.8	**IC10** >100		

Concentration (%)	Mean Total Larvae/mL	% Treatment Mortality	LCp (%)	% Abnormal	ICp (%)	NOEC (%)	TUc
PK Filtered							
6.25	18.9	0.0	**LC50** >100	3.5	**IC50** >100	100	<1.0
12.5	16.8	8.2	**LC40** >100	4.3	**IC40** >100		
25	16.6	9.3	**LC25** >100	3.3	**IC25** >100		
50	19.7	0.0	**LC15** >100	3.6	**IC15** >100		
100	16.9	7.7	**LC10** >100	2.8	**IC10** >100		

PS: Presidio Shoal
PK: Point Knox Shoal
*: Statistically significant.
LC/ICp: Lethal/Inhibition Concentration for p% of the organisms.
NOEC: No Observable Effect Concentration.
TUc: 100%/LC-IC25.
-a: Based on an intermittent dose response.

Table E-1. Continued

Sample Collection September 3, 1993 (Survey 4) / Testing September 3 - 5, 1993

Concentration (%)	Mean Total Larvae/mL	% Treatment Mortality	LCp (%)	% Abnormal	ICp (%)	NOEC (%)	TUc
Control	41.2	NA		7.0			
PS Unfiltered							
6.25	49.8	0.0	**LC50** >100	5.1	**IC50** >100	100	1.2
12.5	46.3	0.0	**LC40** >100	12.8	**IC40** >100		
25	45.5	0.0	**LC25** 86.9	11.7	**IC25** >100		
50	44.7	0.0	**LC15** 70.6 (54.1 - 86.5)	12.4	**IC15** >100		
100	30.7	25.5	**LC10** 62.4 (11.4 - 74.3)	9.0	**IC10** >100		

Concentration (%)	Mean Total Larvae/mL	% Treatment Mortality	LCp (%)	% Abnormal	ICp (%)	NOEC (%)	TUc
PS Filtered							
6.25	38.3	7.0	**LC50** >100	1.9	**IC50** >100	100	<1.0
12.5	35.1	14.8	**LC40** >100	2.1	**IC40** >100		
25	38.5	6.6	**LC25** >100	3.4	**IC25** >100		
50	40.5	1.7	**LC15** >100	1.7	**IC15** >100		
100	41.5	0.0	**LC10** >100	4.5	**IC10** >100		

Concentration (%)	Mean Total Larvae/mL	% Treatment Mortality	LCp (%)	% Abnormal	ICp (%)	NOEC (%)	TUc
PK Unfiltered							
6.25	33.5	18.7	**LC50** >100	4.4	**IC50** >100	100	<1.0
12.5	37.9	8.0	**LC40** >100	6.7	**IC40** >100		
25	37.3	9.5	**LC25** >100	4.4	**IC25** >100		
50	35.1	14.8	**LC15** >100	4.1	**IC15** >100		
100	40.9	0.7	**LC10** < 6.25	5.4	**IC10** >100		

Concentration (%)	Mean Total Larvae/mL	% Treatment Mortality	LCp (%)	% Abnormal	ICp (%)	NOEC (%)	TUc
PK Filtered							
6.25	49.3	0.0	**LC50** >100	6.2	**IC50** >100	100	<1.0
12.5	49.9	0.0	**LC40** >100	10.7	**IC40** >100		
25	57.1	0.0	**LC25** >100	9.2	**IC25** >100		
50	57.1	0.0	**LC15** 99.0	9.1	**IC15** >100		
100	43.1	0.0	**LC10** 82.7	6.3	**IC10** >100		

PS: Presidio Shoal
PK: Point Knox Shoal
*: Statistically significant.
LC/ICp: Lethal/Inhibition Concentration for p% of the organisms.
NOEC: No Observable Effect Concentration.
TUc: 100%/LC-IC25.
( ): 95% Confidence Limits

METHODS

- Water quality depth profiles and water samples for chemical analysis were taken within and outside the effluent plume on a monthly basis for three months. The survey dates were as follows:
  - Survey 1- 2 June 1993
  - Survey 2- 30 June and 1 July 1993
  - Survey 3- 19 and 20 August 1993

- Sampling took place at two stations:
  - Presidio Shoal
  - Point Knox Shoal

- At each station, four locations were sampled:
  - **Upstream (ambient)**- At a point upstream/up current or along side of the effluent plume and not under the influence of discharge, but representative of ambient conditions.
  - **30 m downstream (plume)**- Within 30m downstream of the point of discharge.
  - **Midpoint (plume)**- At a point midpoint in the plume.
  - **Downstream (ambient)**- At a downstream/downcurrent location outside the effluent plume.

- (3 surveys x 2 stations x 4 locations)

Water Quality Depth Profiles

- Water quality measurements were collected at 1m intervals for the following parameters:
  - Temperature
  - Salinity
  - Dissolved oxygen
  - pH
  - Percent transmittance

Chemical Analyses

- Discrete water samples were taken at two depths: one meter below the water surface (surface) and two meters above the bottom (bottom), at both stations at each of the four locations. Water samples were analyzed for the following parameters:
  - Total suspended solids
  - Metals
  - Arsenic
  - Total organic carbon
  - Total sulfides
  - Ammonia

Table E-3. Effluent concentrations of priority pollutant metals. Values are µg/l (ppb).

	Presidio Shoal		Point Knox Shoal		MRL	EPA Method
	Unfiltered	Filtered	Unfiltered	Filtered		
Survey 1 (June 2)						
Arsenic	121	2.7	6.4	1.5	5	200.8M
Cadmium	3.2	0.04	0.35	0.07	0.2	200.8M
Chromium	127	0.2	13.5	0.4	2	200.8M
Copper	232	0.5	21.8	0.9	1	200.8M
Lead	214	0.23	23.2	0.18	0.2	200.8M
Mercury	2.9	ND	0.1	ND	0.1	7470
Nickel	250	1.6	20.2	1.6	2	200.8M
Selenium	6	0.6	0.7	0.7	4	200.8M
Silver	ND	ND	0.11	ND	0.5	200.8M
Zinc	593	9	66	5	10	200.8M
Survey 2 (June 30 - July 1)						
Arsenic	12.1	1.7	2.9	NS	5	200.8M
Cadmium	0.23	0.18	0.16	NS	0.2	200.8M
Chromuim	14.1	0.2	5.6	NS	2	200.8M
Copper	20.2	1.7	5.6	NS	1	200.8M
Lead	16.4	0.41	2.42	NS	0.2	200.8M
Mercury	0.2	ND	ND	NS	0.1	7470
Nickel	19.2	4.9	6.7	NS	2	200.8M
Selenium	ND	ND	ND	NS	4	200.8M
Silver	0.11	ND	0.02	NS	0.5	200.8M
Zinc	36	7	10	NS	10	200.8M
Survey 3 (August 19 - 20)						
Arsenic	77.3	4.1	2.0	1.7	0.5	200.8M
Cadmium	0.43	0.05	0.53	0.12	0.02	200.8M
Chromium	25.8	0.2	0.4	0.6	0.2	200.8M
Copper	32.5	0.6	1.8	1.1	0.1	200.8M
Lead	43.8	0.25	0.75	0.31	0.02	200.8M
Mercury	0.4	0.6	0.2	ND	0.1	7470
Nickel	35.0	1.1	1.2	1.7	0.2	200.8M
Selenium	<1	0.6	ND	ND	0.5	200.8M
Silver	0.15	ND	ND	ND	0.02	200.8M
Zinc	51	9	14	17	1	200.8M

NS = not sampled
ND = not detected

Table E-2. Effluent concentrations of Ammonia, total suspended solids, total sulfides, and total organic carbon. Values are mg/l (ppm).

	Presidio Shoal		Point Knox Shoal		MRL	EPA Method
	Unfiltered	Filtered	Unfiltered	Filtered		
Survey 1 (June 2)						
Ammonia	0.67	0.57	0.20	0.18	0.05	350.3
Total Suspended Solids	10,800	ND	484	ND	5	160.2
Total Sulfides	0.12	ND	ND	ND	0.05	9030
Total Organic Carbon	110	1.5	1.0	ND	0.5	415.1
Survey 2 (June 30 - July 1)						
Ammonia	0.30	0.29	0.17	NS	0.05	350.3
Total Suspended Solids	541	27	173	NS	5	160.2
Total Sulfides	ND	ND	ND	NS	0.05	9030
Total Organic Carbon	<1.0*	<0.5	1.5	NS	0.5	415.1
Survey 3 (August 19 - 20)						
Ammonia	1.63	1.33	0.17	0.22	0.05	350.3
Total Suspended Solids	1,350	ND	493	5	5	160.2
Total Sulfides	0.11	ND	ND	ND	0.05	9030
Total Organic Carbon	1.2	1.1	0.8	1.2	0.5	415.1

NS = not sampled
ND = not detected
*Detection Limit Elevated Due to Matrix Interference

Table E-4. Effluent concentrations of polynuclear aromatic hydrocarbons. Values are μg/l (ppb). EPA method 3510 in combination with GC/MS SIM method

	Presidio Shoal		Point Knox Shoal		MRL
	Unfiltered	Filtered	Unfiltered	Filtered	
SURVEY 1 (June 2)					
Naphthalene	ND	ND	ND	ND	0.1
2-Methylnaphthalene	ND	ND	ND	ND	0.1
Acenaphthylene	ND	ND	ND	ND	0.1
Dibenzofuran	ND	ND	ND	ND	0.1
Acenaphthene	ND	ND	ND	ND	0.1
Fluorene	ND	ND	ND	ND	0.1
Phenanthrene	0.4	ND	0.1	ND	0.1
Anthracene	ND	ND	ND	ND	0.1
Fluoranthene	0.5	ND	0.2	ND	0.1
Pyrene	0.5	ND	0.3	ND	0.1
Benz(a)anthracene	0.2	ND	ND	ND	0.1
Chrysene	0.2	ND	0.1	ND	0.1
Benzo(b+k)fluoranthene	0.4	ND	0.3	ND	0.1
Benzo(a)pyrene	0.3	ND	0.2	ND	0.1
Indeno(1,2,3-cd) pyrene	0.2	ND	0.2	ND	0.1
Dibenzo(a,h)anthracene	ND	ND	ND	ND	0.1
Benzo(g,h,i)perylene	0.3	ND	0.2	ND	0.1
SURVEY 2 (June 30 - July 1)					
Naphthalene	ND	ND	ND	NS	0.1
2-Methylnaphthalene	ND	ND	ND	NS	0.1
Acenaphthylene	ND	ND	ND	NS	0.1
Dibenzofuran	ND	ND	ND	NS	0.1
Acenaphthene	ND	ND	ND	NS	0.1
Fluorene	ND	ND	ND	NS	0.1
Phenanthrene	ND	ND	ND	NS	0.1
Anthracene	ND	ND	ND	NS	0.1
Fluoranthene	0.1	ND	ND	NS	0.1
Pyrene	0.1	ND	ND	NS	0.1
Benz(a)anthracene	ND	ND	ND	NS	0.1
Chrysene	ND	ND	ND	NS	0.1
Benzo(b+k)fluoranthene	ND	ND	ND	NS	0.1
Benzo(a)pyrene	ND	ND	ND	NS	0.1
Indeno(1,2,3-cd) pyrene	ND	ND	ND	NS	0.1
Dibenzo(a,h)anthracene	ND	ND	ND	NS	0.1
Benzo(g,h,i)perylene	ND	ND	ND	NS	0.1

Table E-4. Continued

	Presidio Shoal		Point Knox Shoal		MRL
	Unfiltered	Filtered	Unfiltered	Filtered	
SURVEY 3 (August 19 - 20)					
Naphthalene	ND	ND	ND	ND	0.1
2-Methylnaphthalene	ND	ND	ND	ND	0.1
Acenaphthylene	ND	ND	ND	ND	0.1
Dibenzofuran	ND	ND	ND	ND	0.1
Acenaphthene	ND	ND	ND	ND	0.1
Fluorene	ND	ND	ND	ND	0.1
Phenanthrene	ND	ND	ND	ND	0.1
Anthracene	ND	ND	ND	ND	0.1
Fluoranthene	ND	ND	ND	ND	0.1
Pyrene	ND	ND	ND	ND	0.1
Benz(a)anthracene	ND	ND	ND	ND	0.1
Chrysene	ND	ND	ND	ND	0.1
Benzo(b+k)fluoranthene	ND	ND	0.1	ND	0.1
Benzo(a)pyrene	ND	ND	ND	ND	0.1
Indeno(1,2,3-cd) pyrene	ND	ND	ND	ND	0.1
Dibenzo(a,h)anthracene	ND	ND	ND	ND	0.1
Benzo(g,h,i)perylene	ND	ND	ND	ND	0.1

ND = not detected
NS = not sampled

Table E-5. Concentrations of ammonia as nitrogen in mg/l (ppm) in receiving waters.

Location	Depth	STATION Presidio Shoal	Point Knox Shoal
Survey 1 (June 2)			
Upstream (Ambient)	Surface	0.10	0.09
	Bottom	0.09	0.08
30 m Downstream (Plume)	Surface	0.08	0.10
	Bottom	0.08	0.08
Midpoint (Plume)	Surface	0.10	0.09
	Bottom	0.09	0.08
Downstream (Ambient)	Surface	0.12	0.08
	Bottom	0.08	0.09
Survey 2 (June 30 - July)			
Upstream (Ambient)	Surface	0.09	0.09
	Bottom	0.07	0.07
30 m Downstream (Plume)	Surface	0.09	0.07
	Bottom	0.07	0.06
Midpoint (Plume)	Surface	0.08	0.07
	Bottom	0.10	0.06
Downstream (Ambient)	Surface	0.14	0.07
	Bottom	0.08	0.11
Survey 3 (August 19 - 20)			
Upstream (Ambient)	Surface	0.17	0.16
	Bottom	0.14	0.16
30 m Downstream (Plume)	Surface	0.15	0.16
	Bottom	0.17	0.24
Midpoint (Plume)	Surface	0.18	0.16
	Bottom	0.14	0.16
Downstream (Ambient)	Surface	0.12	0.18
	Bottom	0.12	0.14

EPA Method: 350.3
MRL (Method Reporting Limit): 0.05
ND = None Detected at or above the Method Reporting Limit

Table E-6. Concentrations of total suspended solids (TSS) in mg/l (ppm) in receiving waters.

Location	Depth	STATION Presidio Shoal	Point Knox Shoal
Survey 1 (June 2)			
Upstream (Ambient)	Surface	29	12
	Bottom	29	12
30 m Downstream (Plume)	Surface	24	10
	Bottom	29	7
Midpoint (Plume)	Surface	9	6
	Bottom	72	10
Downstream (Ambient)	Surface	7	9
	Bottom	38	8
Survey 2 (June 30 - July 1)			
Upstream (Ambient)	Surface	34	9
	Bottom	78	13
30 m Downstream (Plume)	Surface	17	12
	Bottom	28	19
Midpoint (Plume)	Surface	34	16
	Bottom	67	18
Downstream (Ambient)	Surface	38	8
	Bottom	70	14
Survey 3 (August 18 - 19)			
Upstream (Ambient)	Surface	8	8
	Bottom	36	12
30 m Downstream (Plume)	Surface	18	5
	Bottom	39	12
Midpoint (Plume)	Surface	12	12
	Bottom	38	14
Downstream (Ambient)	Surface	6	ND
	Bottom	17	16

EPA Method: 160.2
MRL (Method Reporting Limit): 5
ND = None Detected at or above the Method Reporting Limit

Table E-7. Concentrations of total organic carbon (TOC) in mg/l (ppm) in receiving waters.

Location	Depth	STATION Presidio Shoal	Point Knox Shoal
Survey 1 (June 2)			
Upstream (Ambient)	Surface	0.8	0.9
	Bottom	0.7	0.8
30 m Downstream (Plume)	Surface	0.8	0.8
	Bottom	0.7	0.8
Midpoint (Plume)	Surface	0.8	0.8
	Bottom	0.7	0.7
Downstream (Ambient)	Surface	0.7	0.8
	Bottom	0.8	0.7
Survey 2 (June 30 - July 1)			
Upstream (Ambient)	Surface	0.7	0.5
	Bottom	1.7	ND
30 m Downstream (Plume)	Surface	1.1	ND
	Bottom	0.6	ND
Midpoint (Plume)	Surface	0.6	ND
	Bottom	0.5	ND
Downstream (Ambient)	Surface	0.7	ND
	Bottom	ND	ND
Survey 3 (August 19 - 20)			
Upstream (Ambient)	Surface	0.5	0.7
	Bottom	ND	0.7
30 m Downstream (Plume)	Surface	0.6	0.7
	Bottom	0.5	0.6
Midpoint (Plume)	Surface	0.6	0.7
	Bottom	ND	0.7
Downstream (Ambient)	Surface	0.5	0.7
	Bottom	ND	0.6

EPA Method: 415.1
MRL (Method Reporting Limit): 0.5
ND = None Detected at or above the Method Reporting Limit

Table E-8. Values for total metals in µg/l (ppb). In upstream ambient waters.

Metal	Depth	Presidio Shoal	Point Knox Shoal	MRL	EPA Method
Survey 1 (June 2)					
Arsenic	Surface	1.8	1.4	0.5	200.8M
	Bottom	1.5	1.3		
Cadmium	Surface	0.11	0.05	0.02	200.8M
	Bottom	0.08	0.04		
Chromium	Surface	1.0	1.0	0.2	200.8M
	Bottom	1.2	0.3		
Copper	Surface	1.9	1.4	0.1	200.8M
	Bottom	1.6	0.8		
Lead	Surface	11.3	3.13	0.02	200.8M
	Bottom	7.96	0.91		
Mercury	Surface	ND	ND	0.1	7470
	Bottom	ND	ND		
Nickel	Surface	1.4	1.2	0.2	200.8M
	Bottom	1.7	0.4		
Selenium	Surface	ND	0.5	0.4	200.8M
	Bottom	ND	0.7		
Silver	Surface	ND	ND	0.02	200.8M
	Bottom	ND	ND		
Zinc	Surface	28	20	1.0	200.8M
	Bottom	8	4		
Survey 2					
Arsenic	Surface	1.5	1.3	0.5	200.8M
	Bottom	1.9	1.1		
Cadmium	Surface	0.51	0.10	0.02	200.8M
	Bottom	0.13	0.08		
Chromium	Surface	0.4	0.3	0.2	200.8M
	Bottom	1.6	0.5		
Copper	Surface	1.2	1.2	0.1	200.8M
	Bottom	2.2	1.1		
Lead	Surface	0.65	0.65	0.02	200.8M
	Bottom	1.22	0.76		
Mercury	Surface	ND	ND	0.1	7470
	Bottom	ND	ND		
Nickel	Surface	1.1	1.2	0.02	200.8M
	Bottom	2.4	0.6		
Selenium	Surface	ND	ND	0.4	200.8M
	Bottom	ND	ND		
Silver	Surface	ND	ND	0.02	200.8M
	Bottom	ND	ND		
Zinc	Surface	5	14	1.0	200.8M
	Bottom	7	4		

Table E-8. Continued.

Metal	Depth	Presidio Shoal	Point Knox Shoal	MRL	EPA Method
Survey 3					
Arsenic	Surface	1.5	4.0	0.5	200.8M
	Bottom	1.8	1.8		
Cadmium	Surface	0.08	0.21	0.02	200.8M
	Bottom	0.07	0.12		
Chromium	Surface	0.5	12.4	0.2	200.8M
	Bottom	2.1	0.7		
Copper	Surface	1.4	15.2	0.1	200.8M
	Bottom	2.1	1.6		
Lead	Surface	0.65	12.9	0.02	200.8M
	Bottom	1.16	0.55		
Mercury	Surface	ND	ND	0.1	7470
	Bottom	0.6	ND		
Nickel	Surface	1.0	16.9	0.2	200.8M
	Bottom	2.7	1.6		
Selenium	Surface	ND	0.5	0.4	200.8M
	Bottom	ND	ND		
Silver	Surface	0.02	0.05	0.02	200.8M
	Bottom	ND	ND		
Zinc	Surface	4	26	1.0	200.8M
	Bottom	6	7		

M = Modified
MRL = Method Reporting Limit
ND = Not detected at or above the Method Reporting Limit

Table E-9. Values for total metals in µg/l (ppb) in 30m downstream (plume) waters.

Metal	Depth	Presidio Shoal	Point Knox Shoal	MRL	EPA Method
Survey 1 (June 2)					
Arsenic	Surface	1.7	1.4	0.5	200.8M
	Bottom	1.3	1.4		
Cadmium	Surface	0.06	0.05	0.02	200.8M
	Bottom	0.13	0.04		
Chromium	Surface	0.9	0.8	0.2	200.8M
	Bottom	1.2	0.4		
Copper	Surface	1.4	1.5	0.1	200.8M
	Bottom	1.8	1.0		
Lead	Surface	3.71	1.86	0.02	200.8M
	Bottom	16.7	3.41		
Mercury	Surface	ND	ND	0.1	7470
	Bottom	ND	ND		
Nickel	Surface	1.2	1.0	0.2	200.8M
	Bottom	1.7	0.7		
Selenium	Surface	ND	0.5	0.4	200.8M
	Bottom	0.4	0.5		
Silver	Surface	ND	ND	0.02	200.8M
	Bottom	ND	ND		
Zinc	Surface	28	87	1.0	200.8M
	Bottom	26	6		
Survey 2 (June 30-July 1)					
Arsenic	Surface	1.9	1.4	0.5	200.8M
	Bottom	1.7	1.2		
Cadmium	Surface	0.09	0.08	0.02	200.8M
	Bottom	0.08	0.06		
Chromium	Surface	0.7	0.4	0.2	200.8M
	Bottom	1.1	0.8		
Copper	Surface	1.5	1.2	0.1	200.8M
	Bottom	1.5	1.2		
Lead	Surface	0.67	0.89	0.02	200.8M
	Bottom	0.72	1.48		
Mercury	Surface	ND	ND	0.1	7470
	Bottom	ND	ND		
Nickel	Surface	1.7	0.7	0.2	200.8M
	Bottom	1.7	0.7		
Selenium	Surface	ND	ND	0.4	200.8M
	Bottom	ND	ND		
Silver	Surface	ND	ND	0.02	200.8M
	Bottom	ND	ND		
Zinc	Surface	3	39	1.0	200.8M
	Bottom	5	4		

Table E-9. Continued.

Metal	Depth	Presidio Shoal	Point Knox Shoal	MRL	EPA Method
Survey 3 (August 19-20)					
Arsenic	Surface	1.9	1.9	0.5	200.8M
	Bottom	1.9	1.9		
Cadmium	Surface	0.08	0.11	0.02	200.8M
	Bottom	0.17	0.08		
Chromium	Surface	0.9	0.7	0.2	200.8M
	Bottom	2.0	0.6		
Copper	Surface	1.5	1.5	0.1	200.8M
	Bottom	2.4	1.4		
Lead	Surface	0.63	0.42	0.02	200.8M
	Bottom	1.32	0.52		
Mercury	Surface	0.5	ND	0.1	7470
	Bottom	ND	ND		
Nickel	Surface	1.3	1.5	0.2	200.8M
	Bottom	2.3	1.1		
Selenium	Surface	ND	ND	0.4	200.8M
	Bottom	ND	ND		
Silver	Surface	ND	ND	0.02	200.8M
	Bottom	ND	ND		
Zinc	Surface	28	6	1.0	200.8M
	Bottom	11	34		

M = Modified
MRL = Method Reporting Limit
ND = Not detected at or above the Method Reporting Limit

Table E-10. Values for total metals in µg/l (ppb) in midpoint (plume) waters.

Metal	Depth	Presidio Shoal	Point Knox Shoal	MRL	EPA Method
Survey 1 (June 2)					
Arsenic	Surface	1.2	1.6	0.5	200.8M
	Bottom	2.1	1.5		
Cadmium	Surface	0.16	0.05	0.02	200.8M
	Bottom	0.18	0.06		
Chromium	Surface	0.4	0.3	0.2	200.8M
	Bottom	3.3	0.4		
Copper	Surface	1.3	1.1	0.1	200.8M
	Bottom	3.6	0.9		
Lead	Surface	24.1	1.46	0.02	200.8M
	Bottom	7.16	0.91		
Mercury	Surface	ND	ND	0.1	7470
	Bottom	ND	ND		
Nickel	Surface	1.2	0.8	0.2	200.8M
	Bottom	3.3	0.8		
Selenium	Surface	0.5	0.5	0.4	200.8M
	Bottom	0.5	0.6		
Silver	Surface	ND	ND	0.02	200.8M
	Bottom	ND	0.02		
Zinc	Surface	13	22	1.0	200.8M
	Bottom	40	11		
Survey 2 (June 30-July 1)					
Arsenic	Surface	1.7	1.4	0.5	200.8M
	Bottom	1.7	1.0		
Cadmium	Surface	0.08	0.08	0.02	200.8M
	Bottom	0.10	0.06		
Chromium	Surface	0.9	0.6	0.2	200.8M
	Bottom	1.1	0.5		
Copper	Surface	1.5	1.2	0.1	200.8M
	Bottom	1.4	0.7		
Lead	Surface	0.84	0.66	0.02	200.8M
	Bottom	0.80	0.49		
Mercury	Surface	ND	ND	0.1	7470
	Bottom	ND	ND		
Nickel	Surface	1.5	1.3	0.2	200.8M
	Bottom	1.7	0.9		
Selenium	Surface	ND	ND	0.4	200.8M
	Bottom	ND	ND		
Silver	Surface	ND	ND	0.02	200.8M
	Bottom	ND	ND		
Zinc	Surface	7	3	1.0	200.8M
	Bottom	4	2		

Table E-10. Continued.

Metal	Depth	Presidio Shoal	Point Knox Shoal	MRL	EPA Method
Survey 3 (August 19-20)					
Arsenic	Surface	1.8	1.9	0.5	200.8M
	Bottom	1.6	1.8		
Cadmium	Surface	0.09	0.09	0.02	200.8M
	Bottom	0.07	0.07		
Chromium	Surface	0.9	0.9	0.2	200.8M
	Bottom	1.7	0.8		
Copper	Surface	1.5	1.6	0.1	200.8M
	Bottom	1.9	1.5		
Lead	Surface	0.85	1.23	0.02	200.8M
	Bottom	2.29	2.16		
Mercury	Surface	ND	ND	0.1	7470
	Bottom	ND	ND		
Nickel	Surface	1.4	1.2	0.2	200.8M
	Bottom	1.8	1.3		
Selenium	Surface	ND	ND	0.4	200.8M
	Bottom	ND	ND		
Silver	Surface	ND	ND	0.02	200.8M
	Bottom	ND	ND		
Zinc	Surface	20	8	1.0	200.8M
	Bottom	13	13		

M = Modified
MRL = Method Reporting Limit
ND = Not detected at or above the Method Reporting Limit

Table E-11. Values for total metal in μg/l (ppb) in downstream (ambient) waters.

Metal	Depth	Presidio Shoal	Point Knox Shoal	MRL	EPA Method
Survey 1 (June 2)					
Arsenic	Surface	1.6	1.4	0.5	200.8M
	Bottom	1.7	1.3		
Cadmium	Surface	0.09	0.05	0.02	200.8M
	Bottom	0.06	0.04		
Chromium	Surface	0.5	0.3	0.2	200.8M
	Bottom	1.6	0.4		
Copper	Surface	1.6	1.2	0.1	200.8M
	Bottom	2.1	1.0		
Lead	Surface	4.12	0.20	0.02	200.8M
	Bottom	4.31	1.39		
Mercury	Surface	ND	ND	0.1	7470
	Bottom	ND	ND		
Nickel	Surface	1.2	0.8	0.2	200.8M
	Bottom	1.7	0.8		
Selenium	Surface	0.5	0.5	0.4	200.8M
	Bottom	0.7	0.4		
Silver	Surface	ND	ND	0.02	200.8M
	Bottom	ND	ND		
Zinc	Surface	85	22	1.0	200.8M
	Bottom	37	7		
Survey 2					
Arsenic	Surface	1.7	1.0	0.5	200.8M
	Bottom	1.6	1.2		
Cadmium	Surface	0.15	0.06	0.02	200.8M
	Bottom	0.08	0.06		
Chromium	Surface	0.3	0.4	0.2	200.8M
	Bottom	1.5	0.7		
Copper	Surface	1.1	0.7	0.1	200.8M
	Bottom	1.6	0.9		
Lead	Surface	0.39	0.39	0.02	200.8M
	Bottom	1.14	0.69		
Mercury	Surface	ND	ND	0.1	7470
	Bottom	ND	ND		
Nickel	Surface	0.3	0.6	0.2	200.8M
	Bottom	1.8	0.8		
Selenium	Surface	ND	ND	0.4	200.8M
	Bottom	ND	ND		
Silver	Surface	ND	ND	0.02	200.8M
	Bottom	ND	ND		
Zinc	Surface	5	3	1.0	200.8M
	Bottom	4	3		

Table E-11. Continued.

Metal	Depth	Presidio Shoal	Point Knox Shoal	MRL	EPA Method
Survey 3					
Arsenic	Surface	1.6	1.7	0.5	200.8M
	Bottom	1.6	1.7		
Cadmium	Surface	0.08	0.06	0.02	200.8M
	Bottom	0.05	0.06		
Chromium	Surface	0.5	0.4	0.2	200.8M
	Bottom	0.9	0.8		
Copper	Surface	1.2	1.2	0.1	200.8M
	Bottom	1.2	1.3		
Lead	Surface	0.63	1.96	0.02	200.8M
	Bottom	0.47	0.80		
Mercury	Surface	ND	ND	0.1	7470
	Bottom	ND	ND		
Nickel	Surface	0.9	0.9	0.2	200.8M
	Bottom	1.2	1.2		
Selenium	Surface	ND	ND	0.4	200.8M
	Bottom	ND	ND		
Silver	Surface	ND	ND	0.02	200.8M
	Bottom	ND	ND		
Zinc	Surface	5	6	1.0	200.8M
	Bottom	3	5		

M = Modified
MRL = Method Reporting Limit
ND = Not detected at or above the Method Reporting Limit

APPENDIX F

Results of USGS Suspended Sediment Monitoring

SUSPENDED PARTICULATE MATTER
DATA DOCUMENTATION

1 DATA SOURCES

1.1 Suspended Particulate Matter

Suspended Particulate Matter (SPM) data were obtained from the USGS Water Resources Website at the following URL:

http://sfbay.wr.usgs.gov/access/wqdata/index.html**.**

Citations for these data are contained in the References.

Data were extracted from the website through the Database Query link, requesting the following fields: Date, Time, Station Number, and Calculated SPM. A map showing the locations of all USGS Stations is shown in Figure 1. The extracted data were imported into a Microsoft Access 2000 database table. The table was sorted according to Station Number and Date in order to re-extract subsets of data for 11 discrete stations that would be used in the analysis. These stations are indicated by an * in Table 1.

Station 649 (Sacramento River) was selected as an index riverine station; Stations 2 (Chain Island), 3 (Pittsburg), 4 (Simmons Point), 5 (Middle Ground), and 6 (Roe Island) were selected as representative stations in the Suisun/West Delta Area above the Benicia Bridge (see Figure 2); Stations 9 (Benicia) and 10 (Crockett) were selected as representative stations in the San Pablo Bay Area between the Benicia Bridge and the Richmond/San Rafael Bridge (see Figure 3); and Stations 18 (Point Blunt), 19 (Golden Gate), and 20 (Blossom Rock) were selected as representative stations within the Central Bay Area between the Richmond/San Rafael Bridge, the Golden Gate Bridge, and the San Francisco/Oakland Bay Bridge (see Figure 4).

1.2 Delta Outflow Index

The Delta Outflow Index in m^3/sec from 1988 through 1997 was extracted from the same Database Query as above. These data were obtained by USGS from the Interagency Ecological Program (IEP) Dayflow website at URL:

http://iep.water.ca.gov/dayflow/

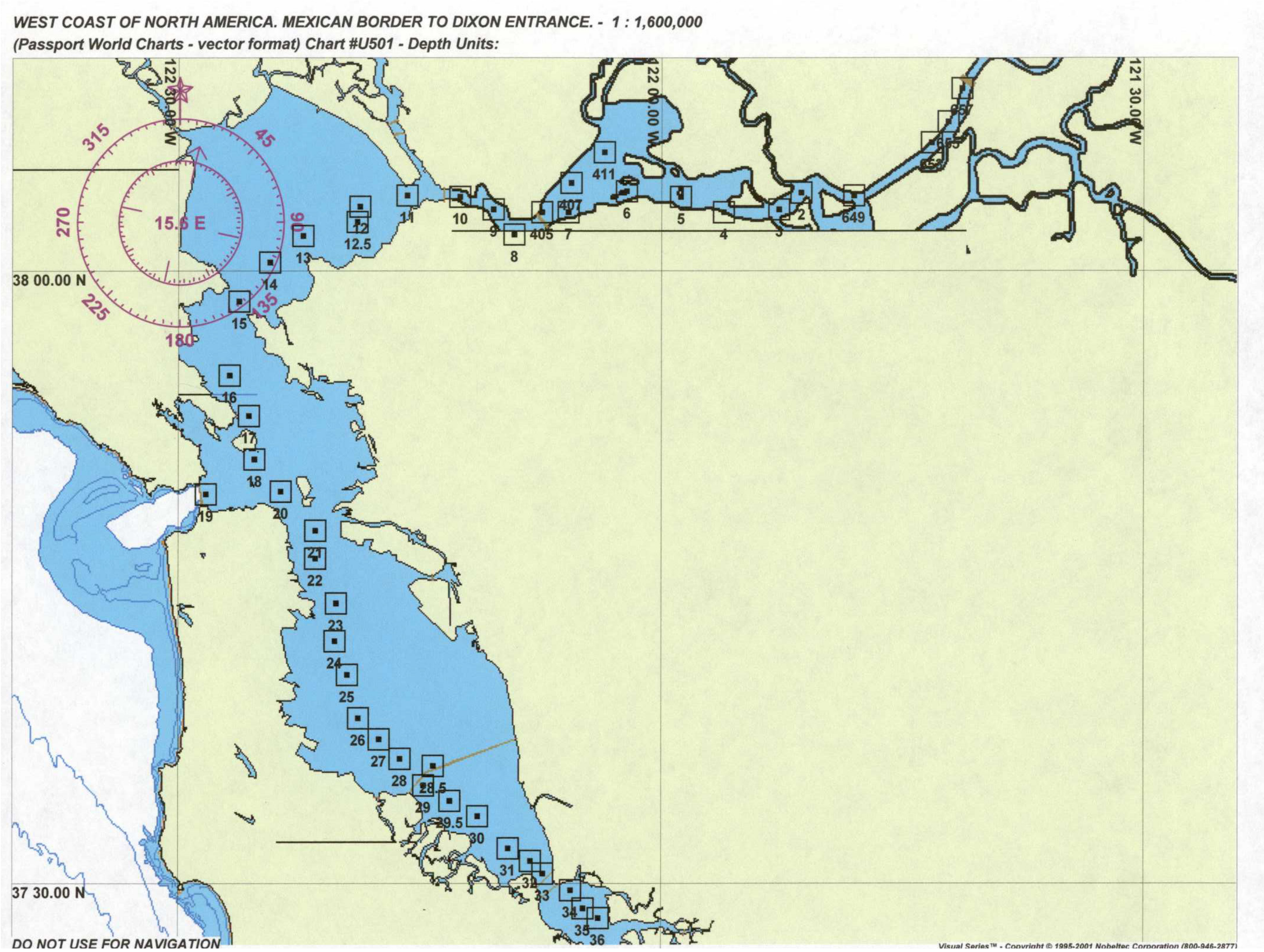


Figure 1. USGS Stations – San Francisco Bay Area

Table 1. USGS Water Quality Stations in San Francisco Bay

Station Number	General Location	North Latitude	West Longitude	Depth (meters)
657	Rio Vista	38° 8.9'	121° 41.3'	10.1
655	N. of Three Mile Slough	7.3'	42.1'	10.1
653	Mid-Decker Island	6.3'	43.2'	10.1
649*	Sacramento River	3.7'	48.0'	10.1
2*	Chain Island	3.8'	51.3'	11.3
3*	Pittsburg	3.0'	52.7'	11.3
4*	Simmons Point	2.9'	56.1'	11.6
5*	Middle Ground	3.6'	58.8'	9.8
6*	Roe Island	3.9'	122° 2.1'	10.1
7	Avon Pier	2.9'	5.8'	11.6
411	Garnet Sill	5.8'	3.5'	
407	Reserve Fleet 4	4.3'	5.6'	
405	Reserve Fleet 2	2.9'	7.4'	
8	Martinez	1.8'	9.1'	14.3
9*	Benicia	3.0'	10.4'	34.4
10*	Crockett	3.6'	12.5'	17.7
11	Mare Island	3.7'	15.8'	15.5
12	Pinole Shoal	3.1'	18.7'	8.8
12.5	Pinole Point (non-standard)	2.4'	18.9'	6.7
13	N. of Pinole Point	1.7'	22.2'	9.8
14	"Echo" Buoy	0.4'	24.3'	13.1
15	Point San Pablo	37° 58.5'	26.2'	22.9
16	"Charlie" Buoy	54.9'	26.8'	12.8
17	Raccoon Strait	52.9'	25.6'	32
18*	Point Blunt	50.8'	25.3'	43
19*	Golden Gate	49.1'	28.3'	91
20*	Blossom Rock	49.2'	23.6'	18.2
21	Bay Bridge	47.3'	21.5'	17.4
22	Potrero Point	45.9'	21.5'	18
23	Hunter's Point	43.7'	20.2'	20.1
24	Candlestick Point	41.9'	20.3'	11
25	Oyster Point	40.2'	19.5'	8.8
26	San Bruno Shoal	38.1'	18.8'	9.8
27	San Francisco Airport	37.1'	17.5'	13
28	N. of San Mateo Bridge	36.1'	16.2'	16.2
28.5	Geo Probe (non-standard)	35.8'	14.1'	15.7
29	S. of San Mateo Bridge	34.8'	14.7'	14.6
29.5	Steinberger Slough (non-standard)	34.1'	13.1'	14.6
30	Redwood Creek	33.3'	11.4'	12.8
31	Coyote Hills	31.7'	9.5'	13.7
32	Ravenswood Point	31.1'	8.0'	12.8
33	Dumbarton Bridge	30.5'	7.3'	11.6
34	Newark Slough	29.7'	5.6'	7.9
35	Mowry Slough	28.8'	4.8'	8.5
36	Calaveras Point	28.3'	3.9'	7.9

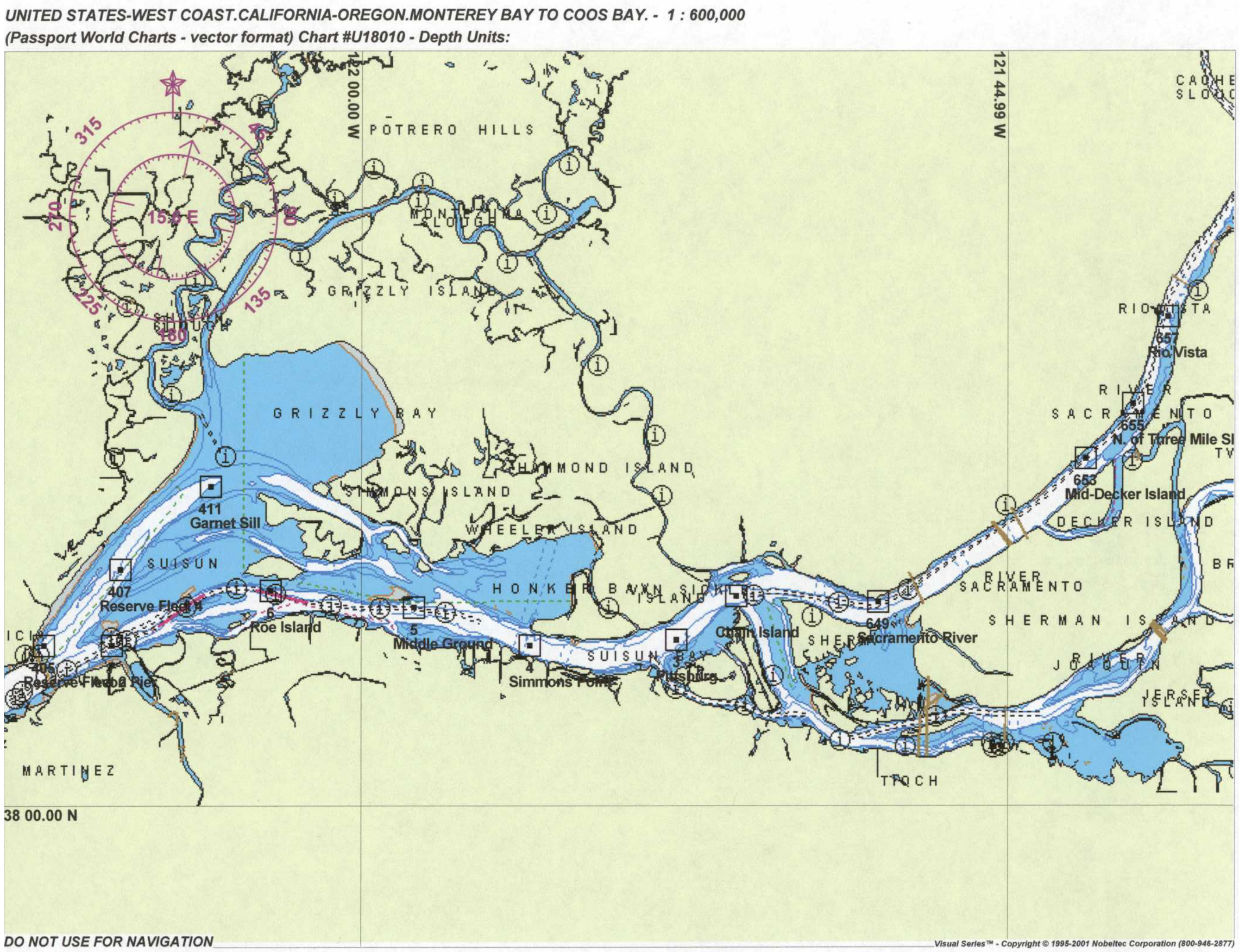


Figure 2. USGS Stations – Suisun Bay/West Delta Area

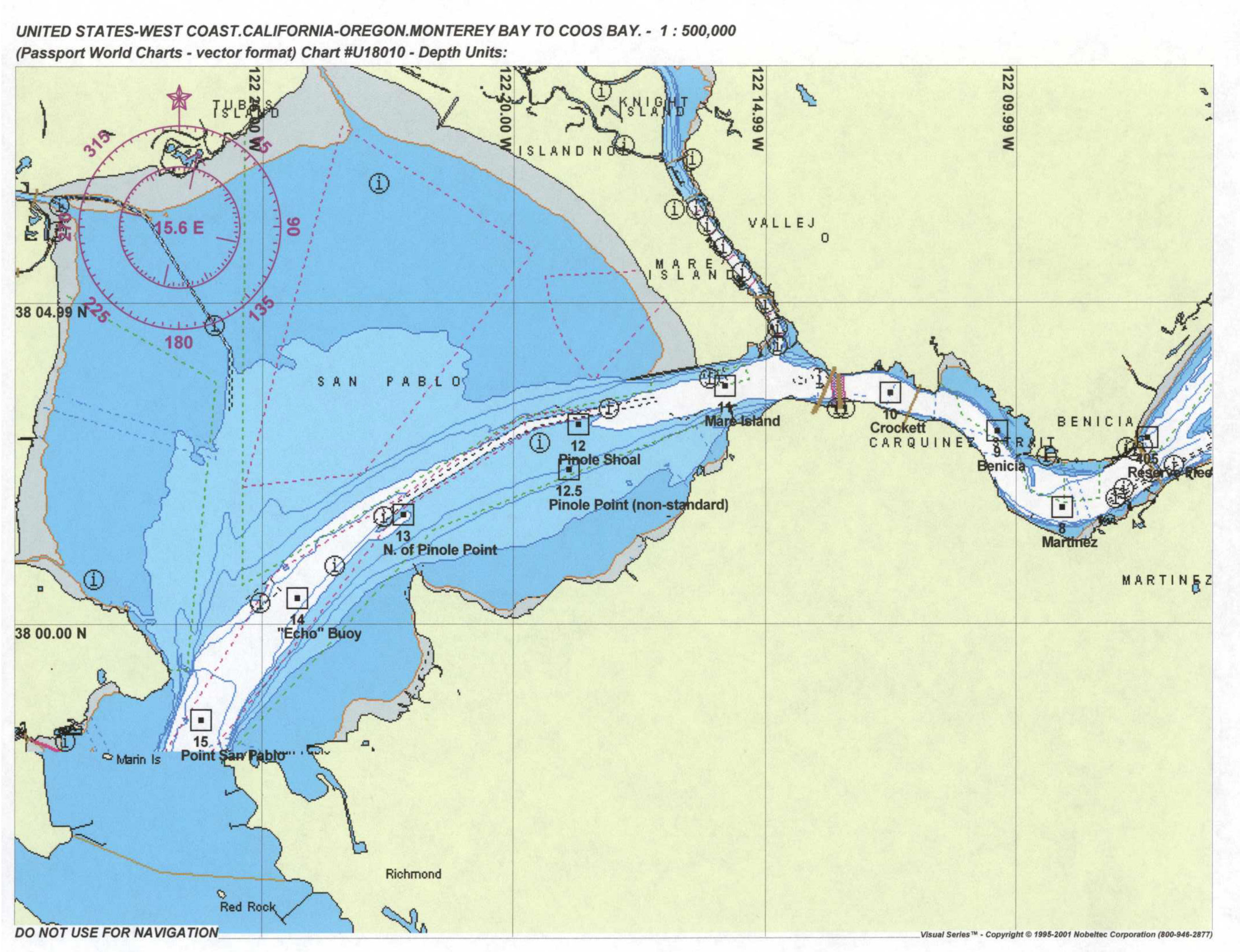


Figure 3. USGS Stations – San Pablo Bay Area

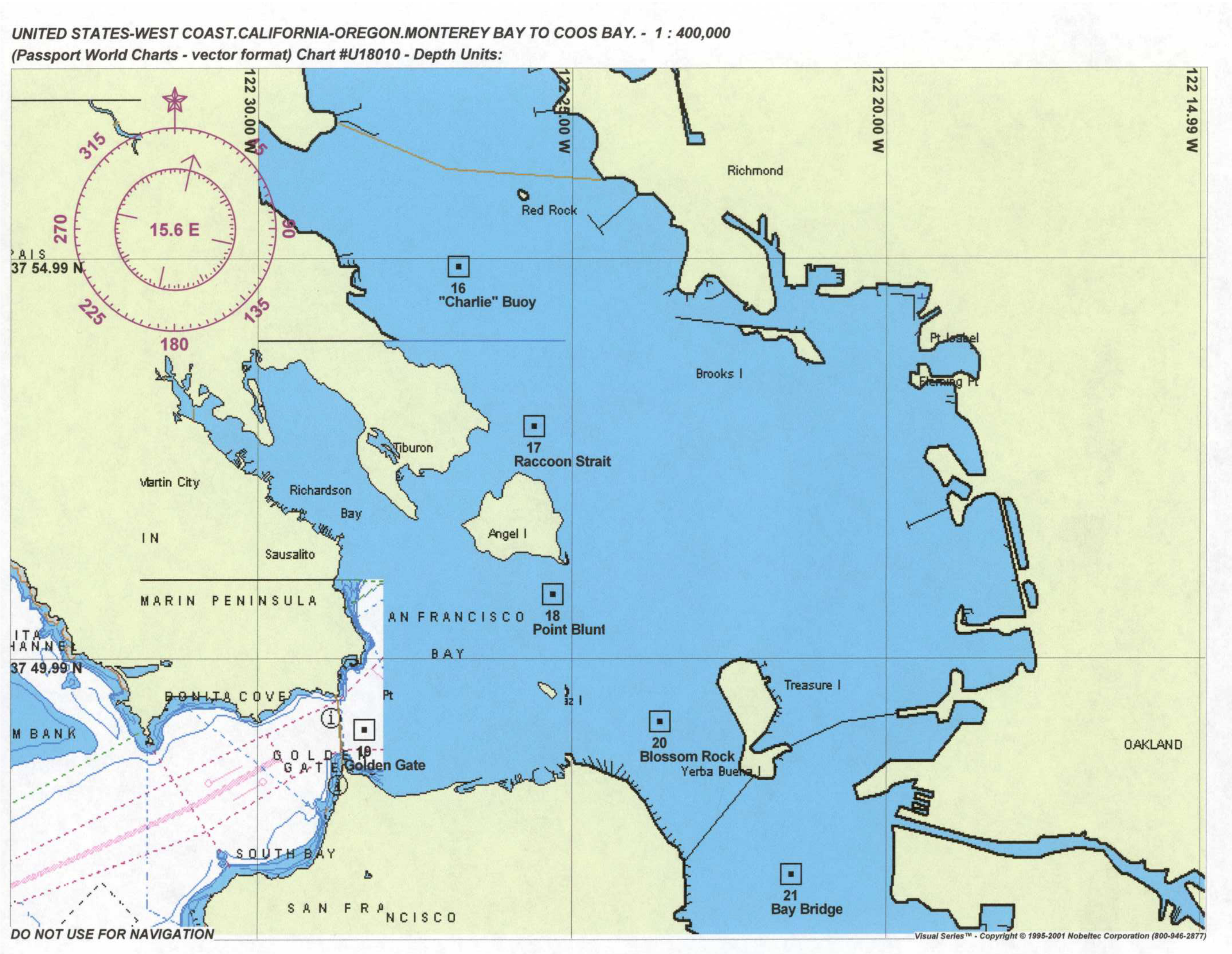


Figure 4. USGS Stations – Central Bay Area

The program documentation for Dayflow is contained at the following URL:

http://iep.water.ca.gov/dayflow/documentation/dayflowDoc.html#Computational%20Scheme%20Part%201

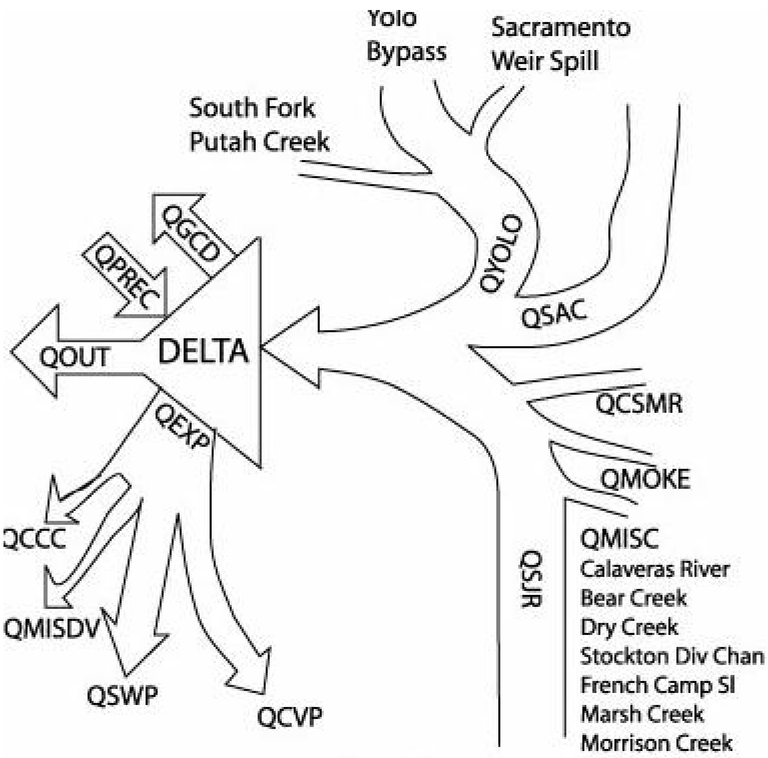
In summary, the Dayflow program provides an estimate of historical mean daily flows in several locations, including past Chipps Island to San Francisco Bay. This location determines Net Delta Outflow, and is determined from the following equation:

QOUT = QTOT + QPREC - QGCD - QEXPORTS - QMISDV

Where:

- QOUT Net Delta outflow at Chipps Island
- QTOT Total Delta inflow
- QPREC Delta precipitation runoff estimate
- QGCD Deltawide gross channel depletion estimate (consumptive use)
- QEXPORTS Total Delta exports and diversions/transfers
- QMISDV flooded island and island Storage diversion

According to the following Delta Hydraulic Scheme:



Delta Hydraulic Scheme used in Dayflow

2 DATA ANALYSIS

The SPM data extracted from the USGS database for each of the 11 stations were sorted by date and then by depth. The data were then examined to find an appropriate time series that contained the most consistent and complete set of results. With two exceptions, the years from 1993 through 2001 contained the most complete time series. The first exception – Station 19 (Golden Gate) had an inconsistent data record, and the most representative record, from 1974 through 1980 was used. The second exception – Station 20 (Blossom Rock) had the most consistent record from 1995 through 2001.

Three depths at each station were chosen to represent surface, mid-depth, and near-bottom samples, while maintaining the most complete data record for each depth. The following table shows the depths analyzed at each of the selected stations:

Station No.	Description	Depths Analyzed (m)
649	Sacramento River	1, 5, 10
2	Chain Island	1, 5, 10
3	Pittsburg	1, 5, 10
4	Simmons Point	1, 5, 10
5	Middle Ground	1, 5, 10
6	Roe Island	1, 5, 10
9	Benicia	1, 10, 25
10	Crockett	1, 10, 18
18	Point Blunt	1, 10, 25
19	Golden Gate	1, 10, 20
20	Blossom Rock	1, 10, 25

The data record for each station with the selected depths was exported from the Access database into SPSS SigmaPlot Version 7, and plots of SPM vs time were generated for each depth. The resulting plots are shown in Figures 5 through 15.

As a means of comparison of Suspended Particulate Matter to flow, the Delta Outflow Index was imported to SigmaPlot and plotted for the same years as Station 18 (Point Blunt). A plot of SPM vs time for all three depths at Station 18, along with a plot of Delta Outflow vs time for the same time period, is shown in Figure 16.

Finally, the same data sets for each station were exported to SigmaStat Version 2, and descriptive statistics for Suspended Particulate Matter were calculated for each depth at each Station. These results are shown in Tables 2 through 12.

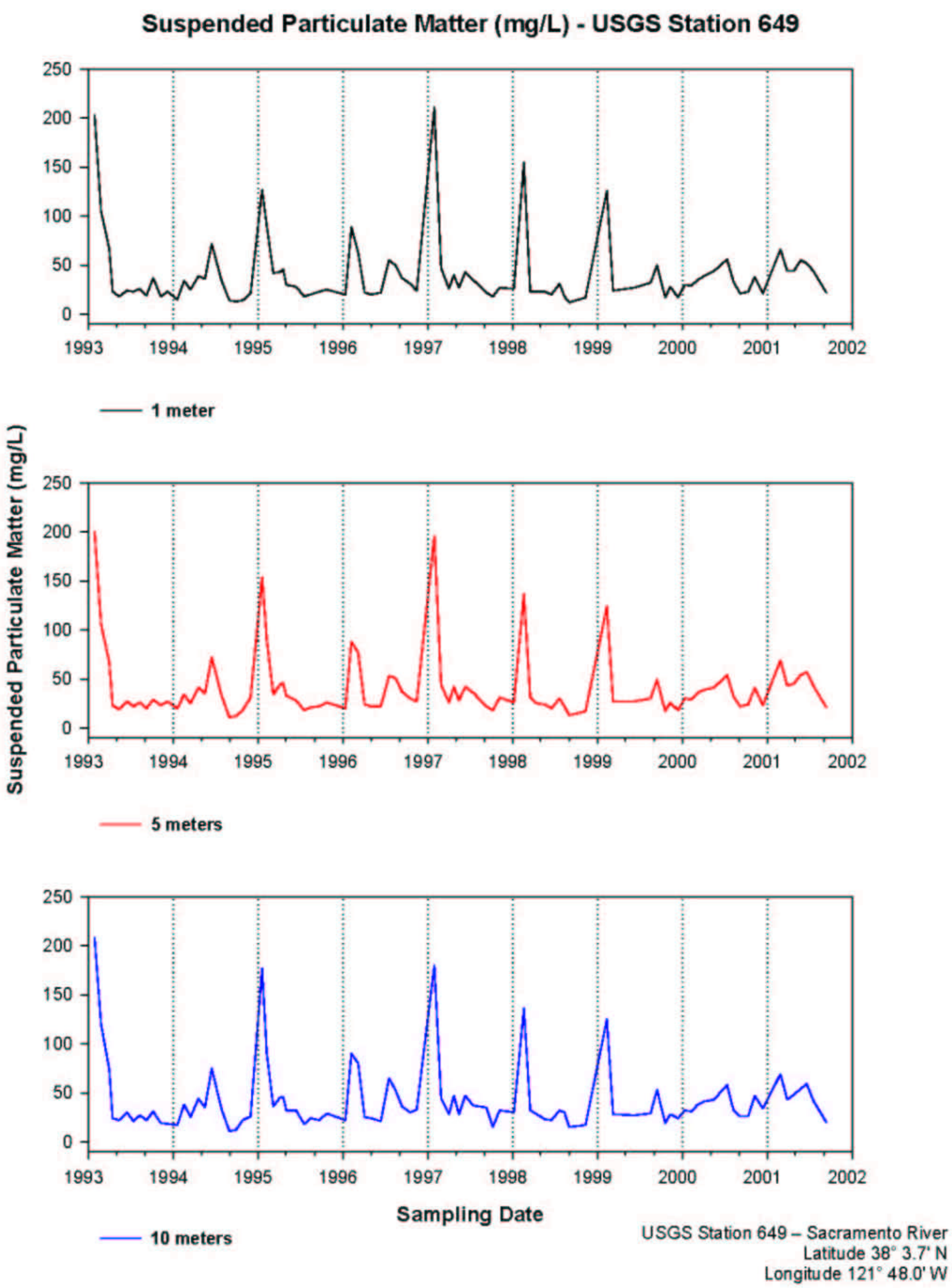


Figure 5. Station 649 SPM Plots

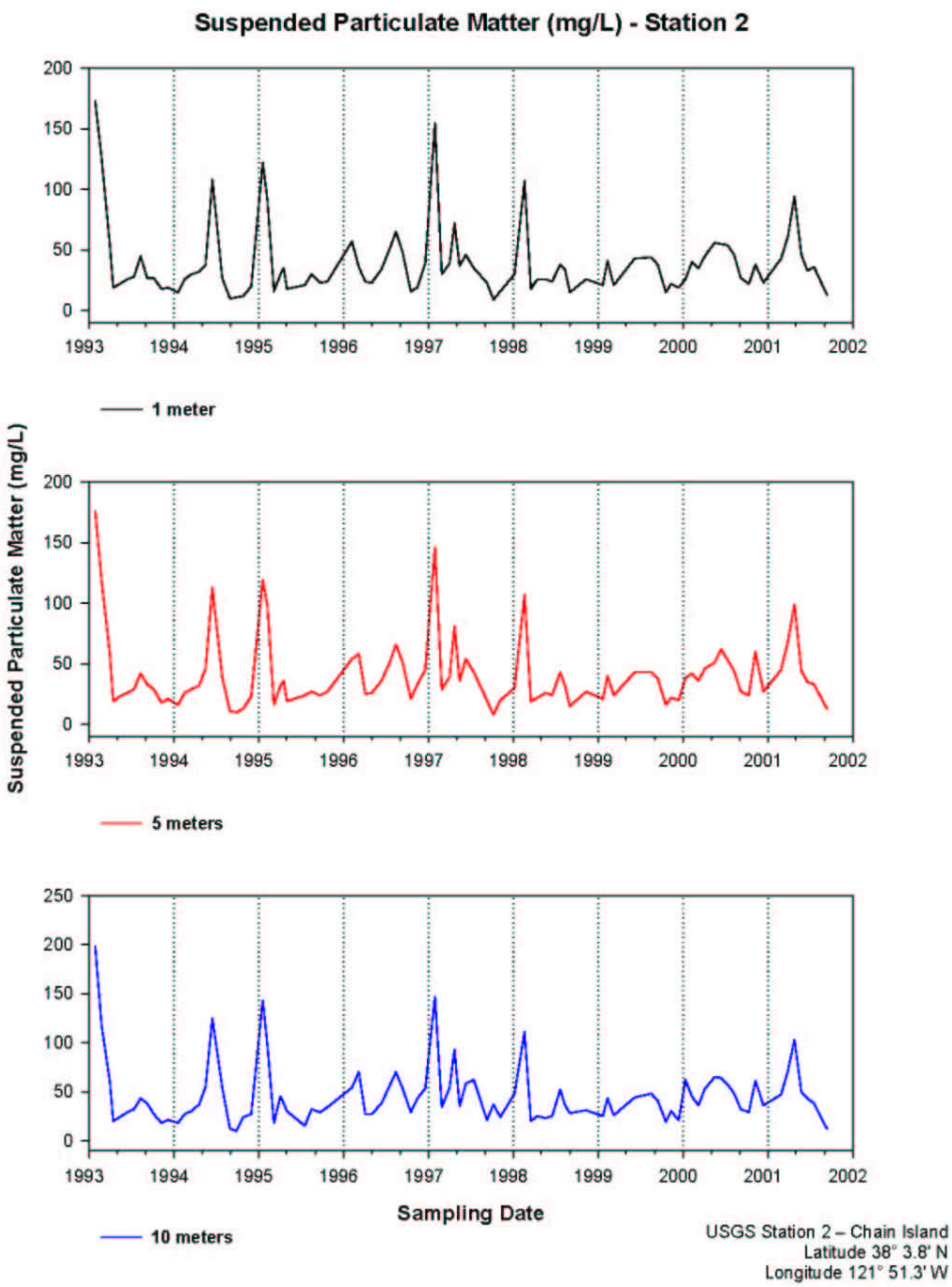


Figure 6. Station 2 SPM Plots

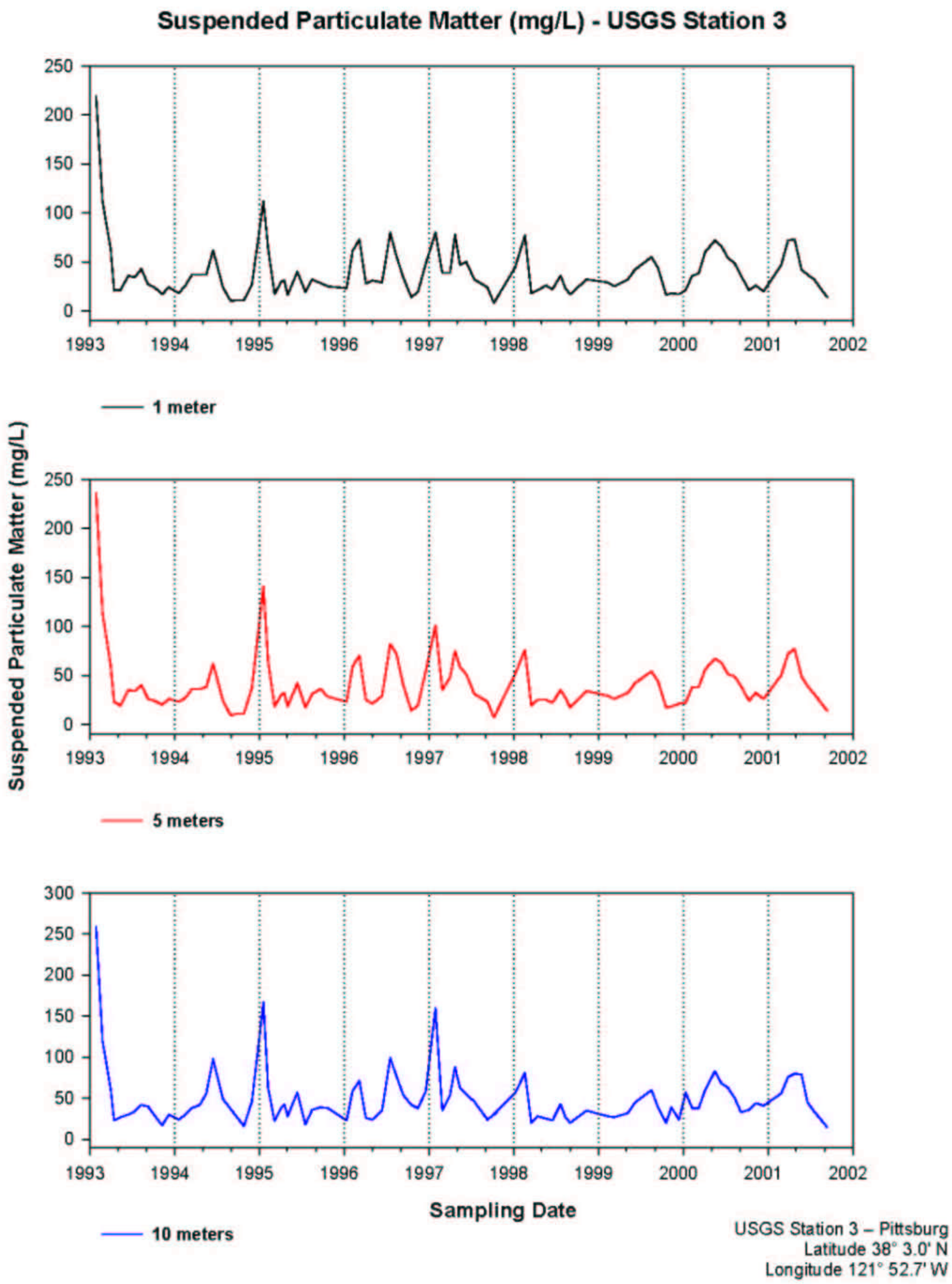


Figure 7. Station 3 SPM Plots

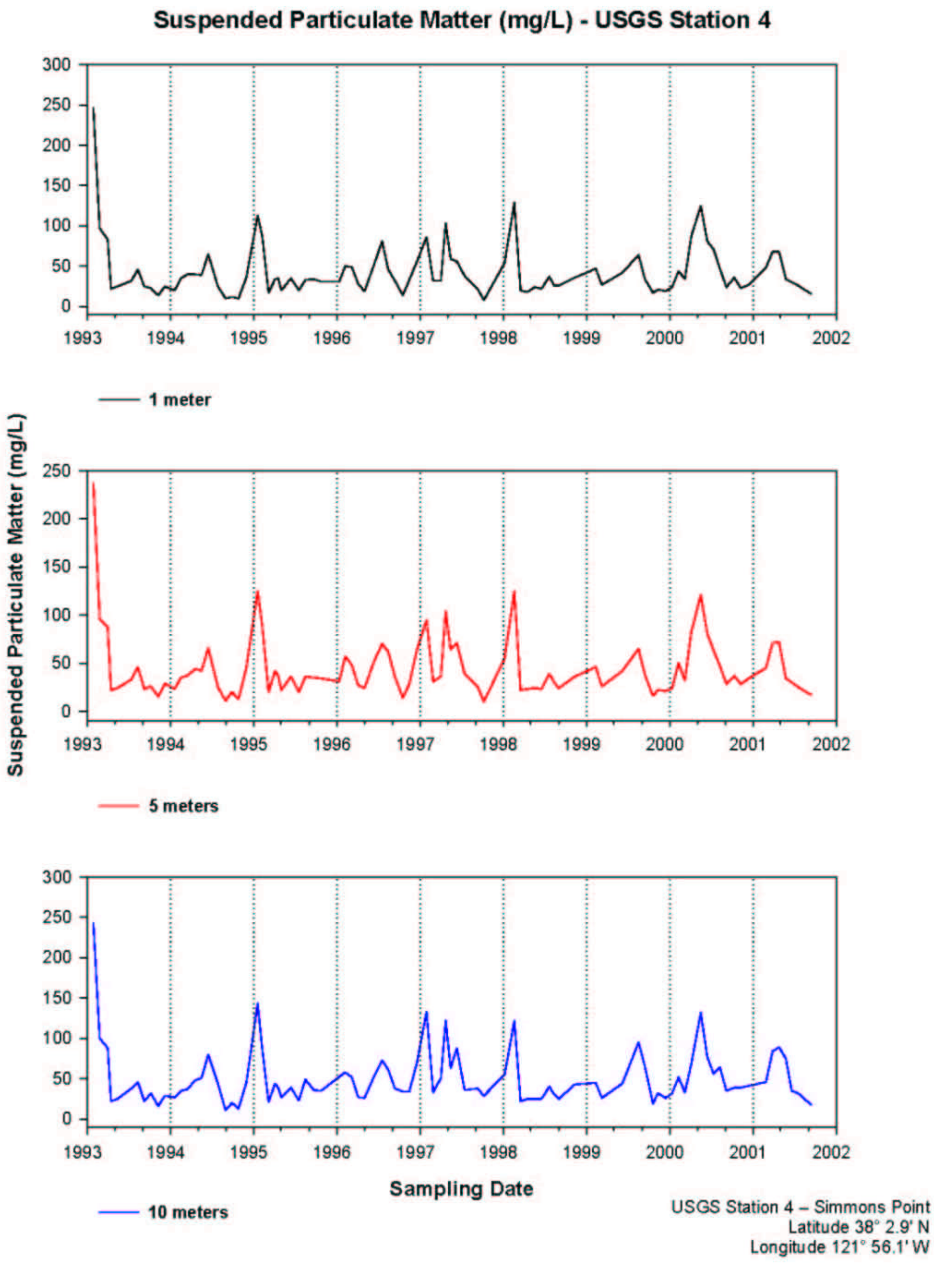


Figure 8. Station 4 SPM Plots

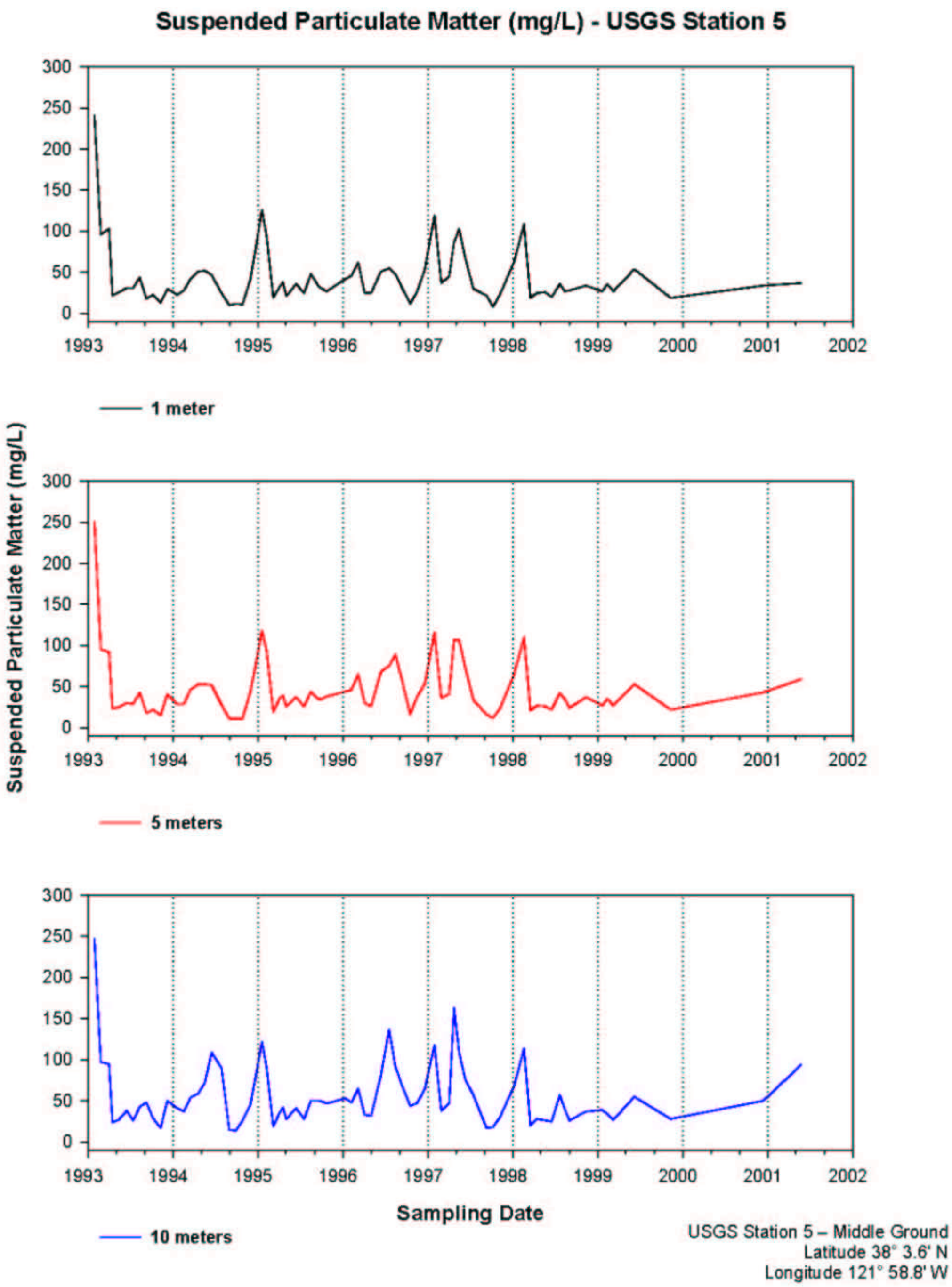


Figure 9. Station 5 SPM Plots

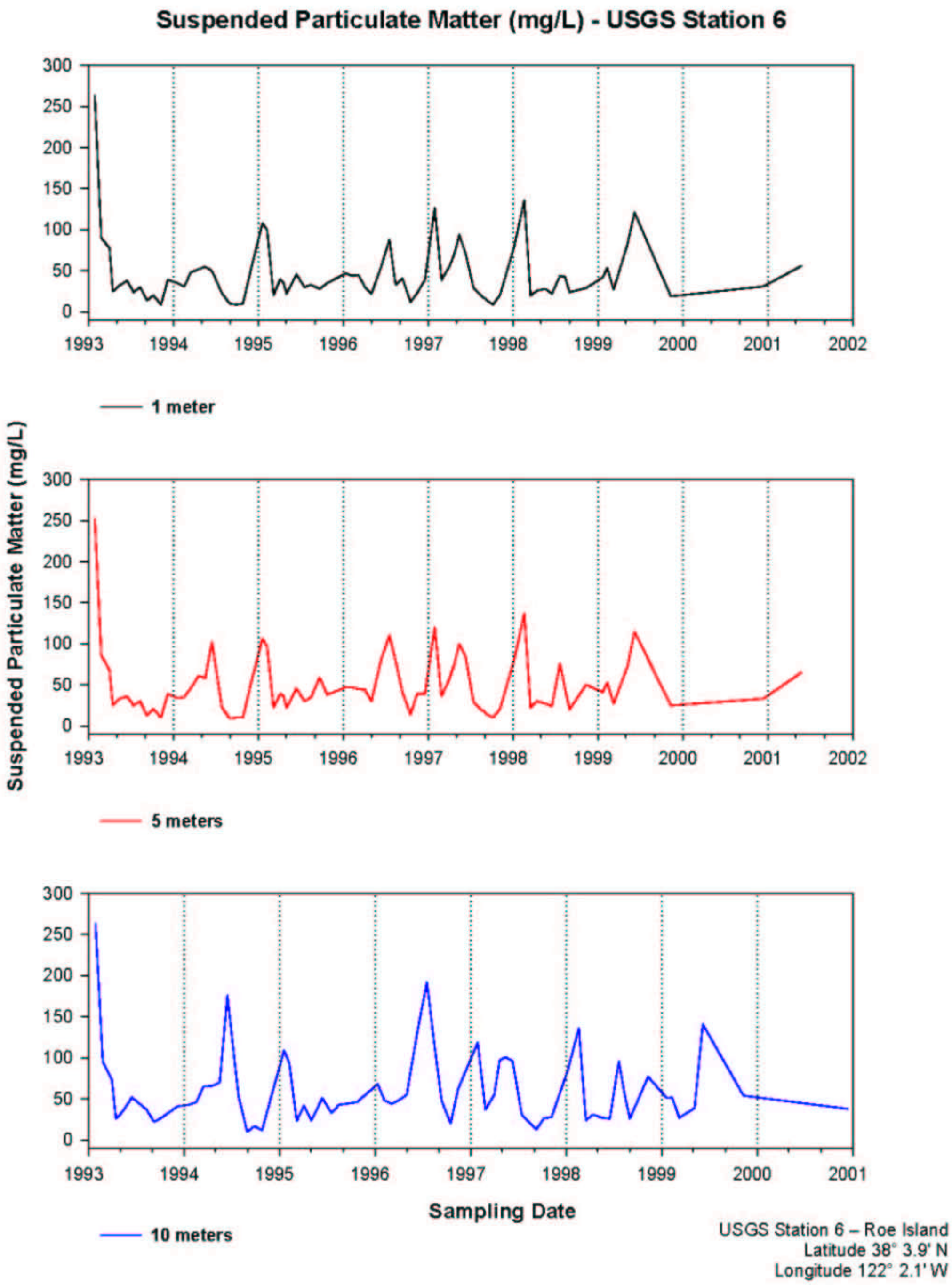


Figure 10. Station 6 SPM Plots

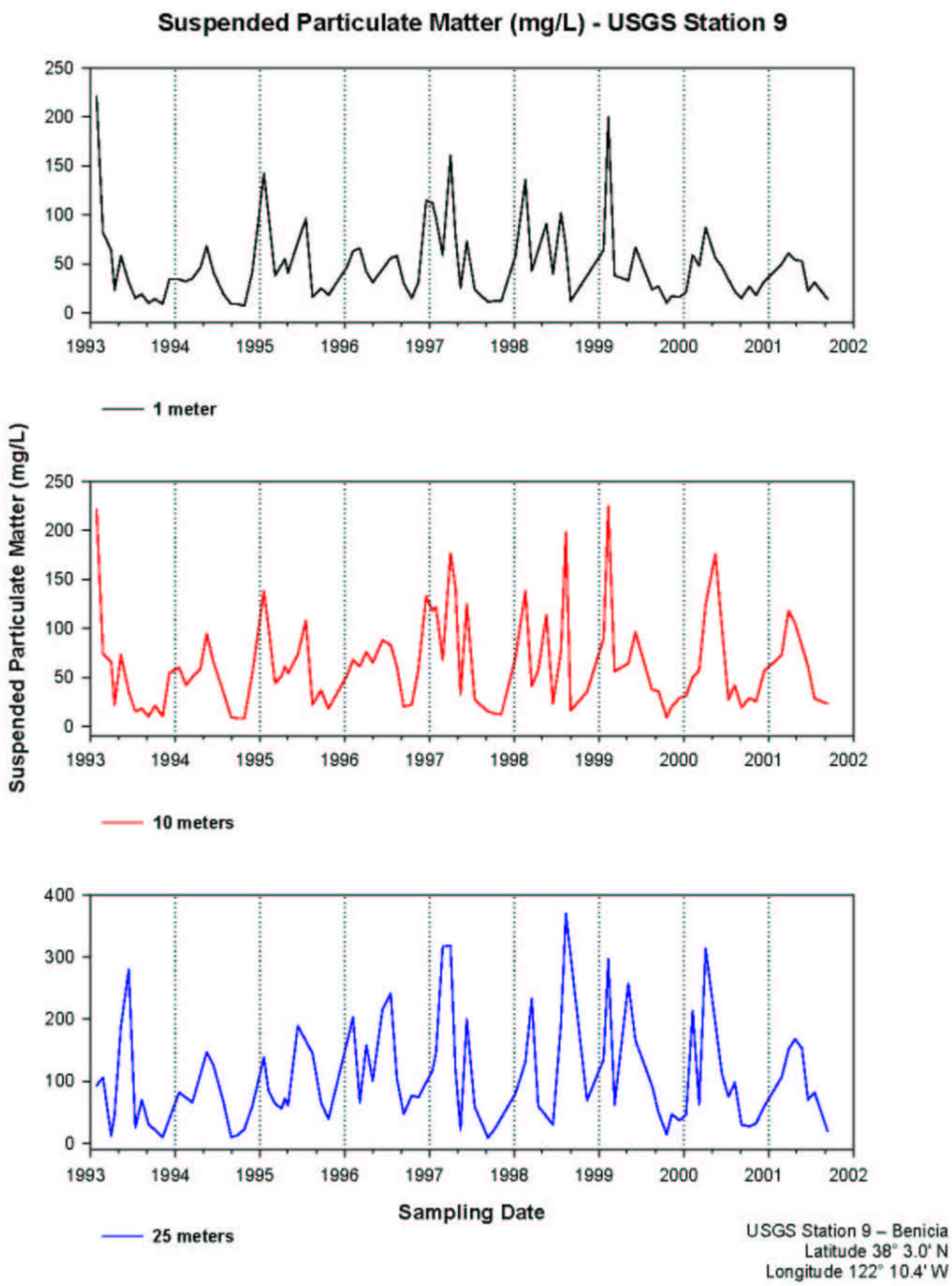


Figure 11. Station 9 SPM Plots

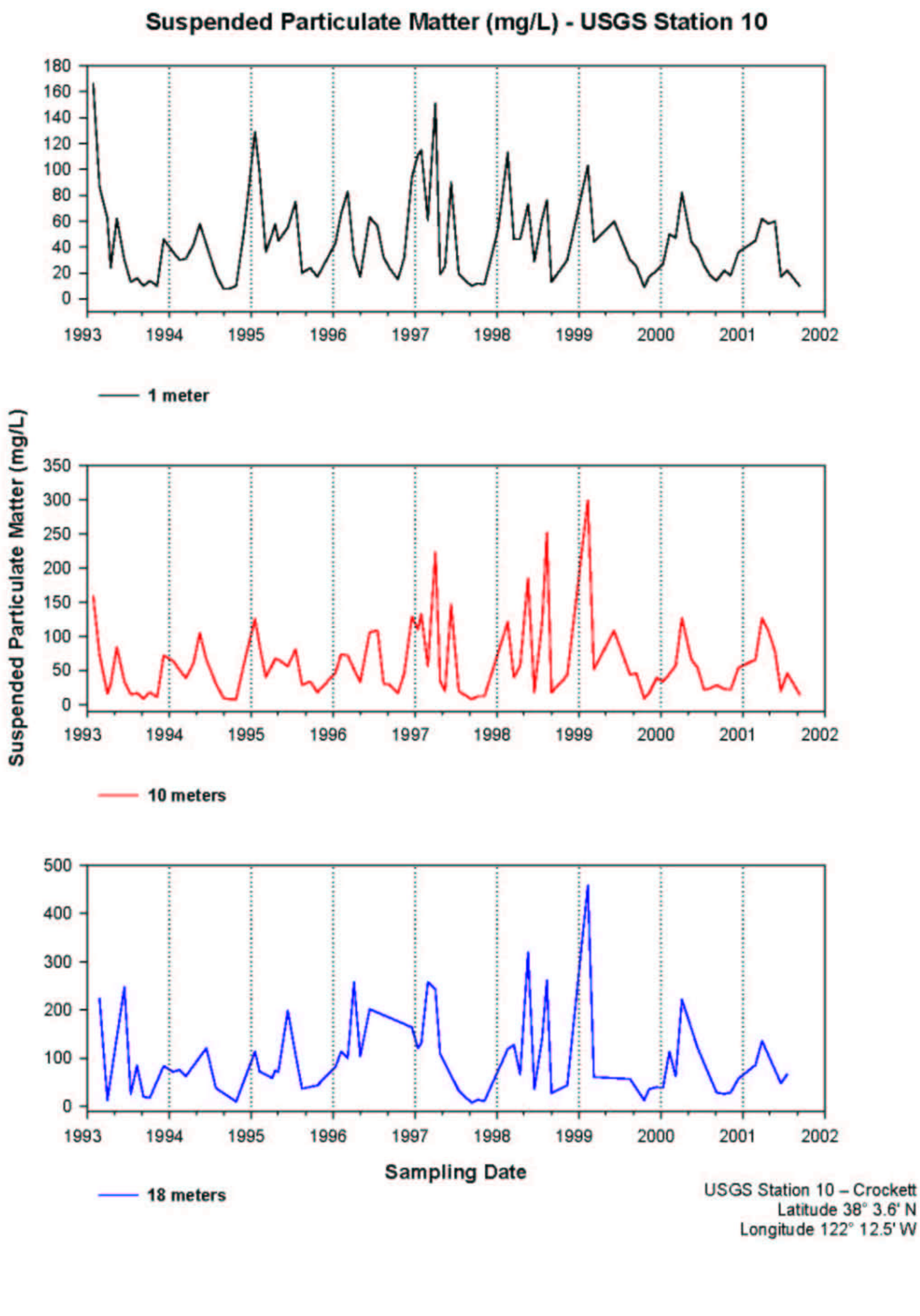


Figure 12. Station 10 SPM Plots

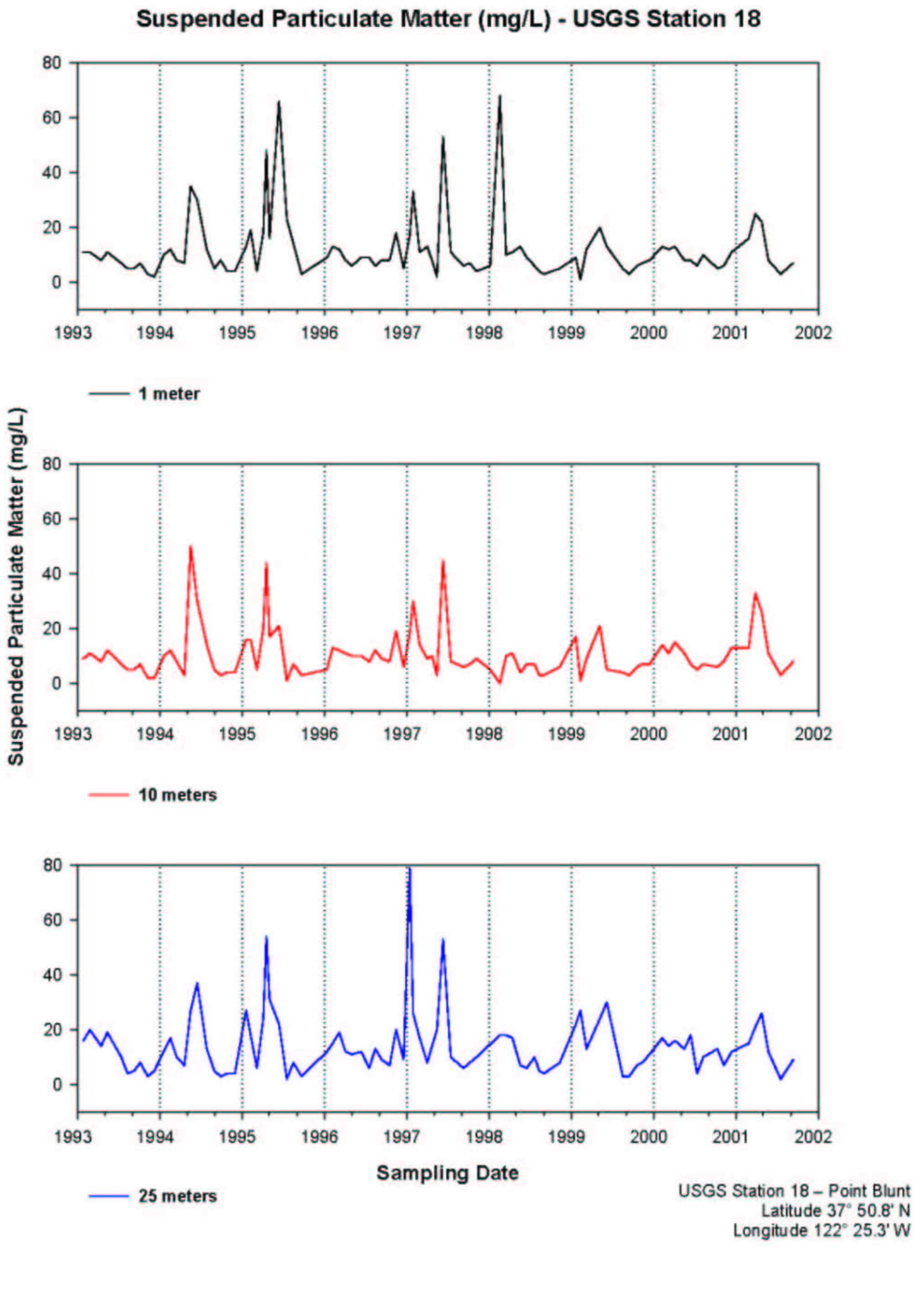


Figure 13. Station 18 SPM Plots

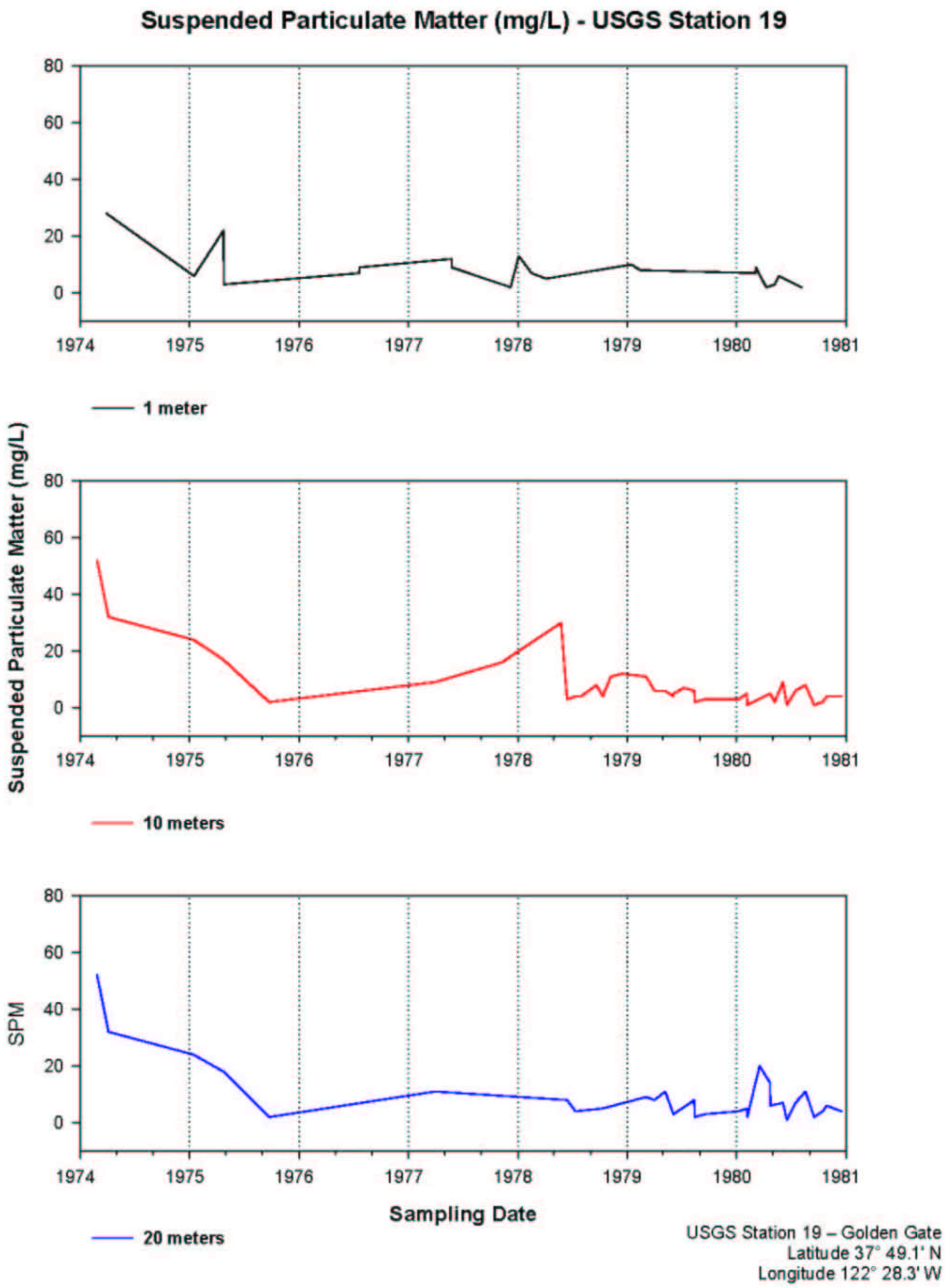


Figure 14. Station 19 SPM Plots

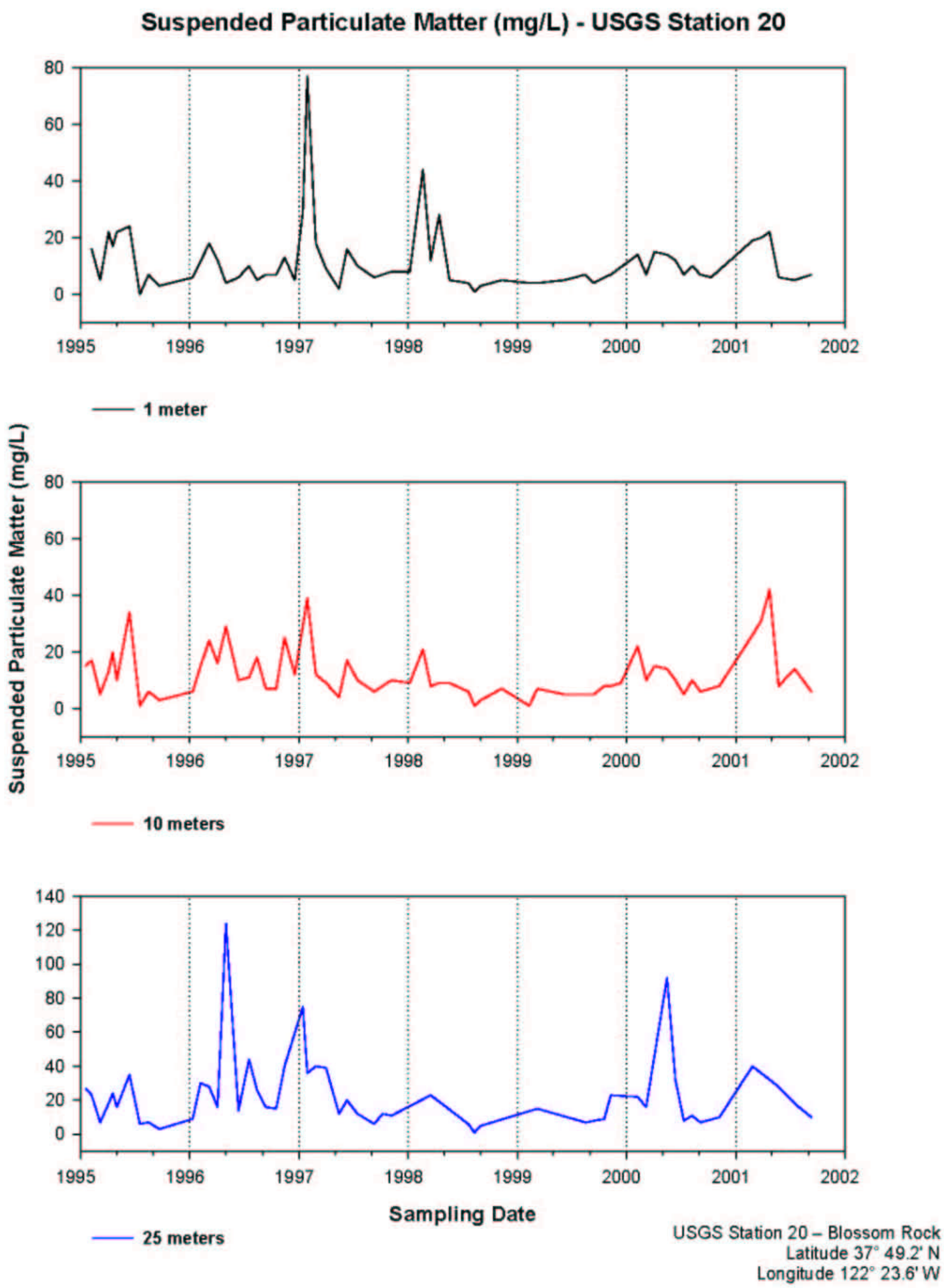


Figure 15. Station 20 SPM Plots

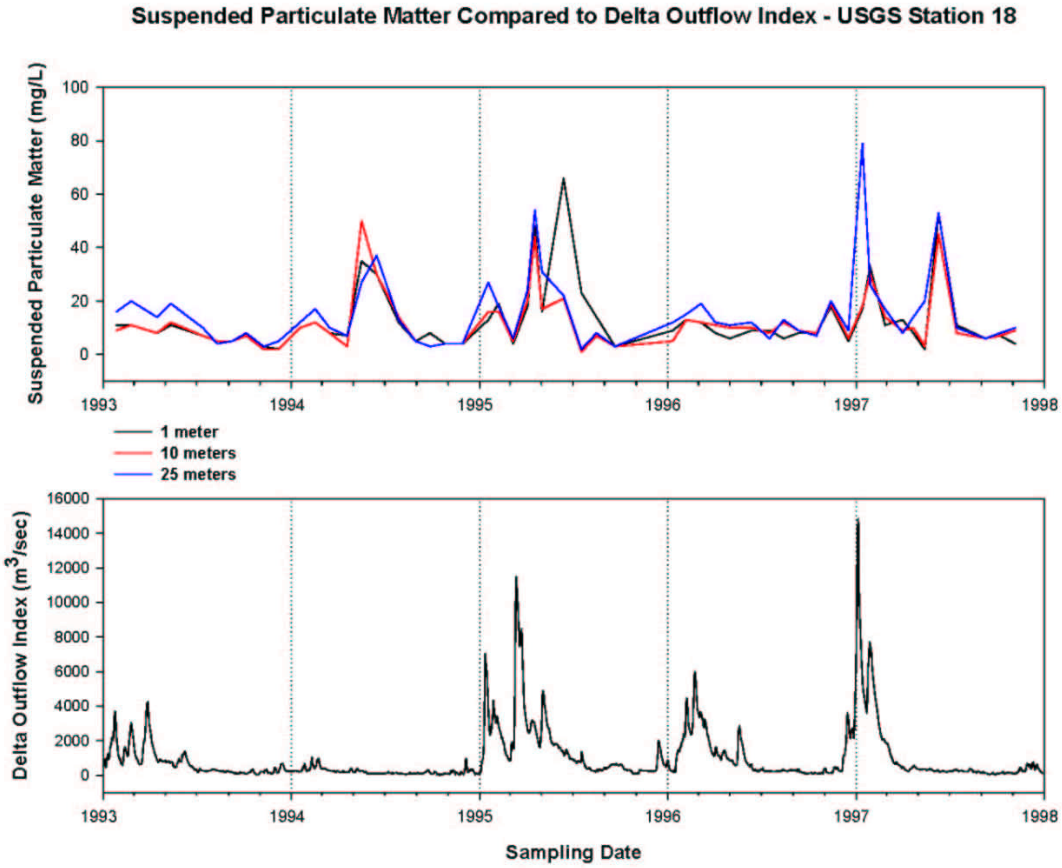


Figure 16. Station 18 SPM Plot and Delta Outflow

Table 2. Descriptive Statistics Station 649 Sacramento River):

Data source: Station 649 - 1 meter in USGS Water Quality

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
SPM (mg/L)*	90	0	40.767	35.859	3.78	7.51

Column	Range	Max	Min	Median	25%	75%
SPM (mg/L)	199	211	12	28.5	22	44

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum of Squares
SPM (mg/L)	3.029	10.343	0.242	<0.001	3669	264013

Data source: Station 649 - 5 meters in USGS Water Quality

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
SPM (mg/L)	91	0	41.088	34.857	3.654	7.259

Column	Range	Max	Min	Median	25%	75%
SPM (mg/L)	189	200	11	30	22.25	43

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum of Squares
SPM (mg/L)	2.92	9.35	0.247	<0.001	3739	262977

Data source: Station 649 - 10 meters in USGS Water Quality

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
SPM (mg/L)	90	0	43.333	35.74	3.767	7.486

Column	Range	Max	Min	Median	25%	75%
SPM (mg/L)	197	208	11	32	24	46

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum of Squares
SPM (mg/L)	2.803	8.532	0.248	<0.001	3900	282686

*SPM - Suspended Particulate Matter

Table 3. Descriptive Statistics Station 2 (Chain Island):

Data source: Station 2 - 1 meter in USGS Water Quality

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
SPM (mg/L)*	91	0	38.923	30.004	3.145	6.249

Column	Range	Max	Min	Median	25%	75%
SPM (mg/L)	164	173	9	30	22	43.75

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum of Squares
SPM (mg/L)	2.477	6.83	0.22	<0.001	3542	218886

Data source: Station 2 - 5 meters in USGS Water Quality

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
SPM (mg/L)	92	0	41.011	29.737	3.1	6.158

Column	Range	Max	Min	Median	25%	75%
SPM (mg/L)	168	176	8	32.5	23.5	45.5

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum of Squares
SPM (mg/L)	2.278	6.007	0.205	<0.001	3773	235203

Data source: Station 2 - 10 meters in USGS Water Quality

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
SPM (mg/L)	92	0	46.304	31.65	3.3	6.555

Column	Range	Max	Min	Median	25%	75%
SPM (mg/L)	188	198	10	37.5	27	54

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum of Squares
SPM (mg/L)	2.303	6.695	0.165	<0.001	4260	288414

*SPM - Suspended Particulate Matter

Table 4. Descriptive Statistics Station 3 (Pittsburg):

Data source: Station 3 - 1 meter in USGS Water Quality

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
SPM (mg/L)*	92	0	39.457	28.518	2.973	5.906

Column	Range	Max	Min	Median	25%	75%
SPM (mg/L)	211	219	8	32	21.5	47.5

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum of Squares
SPM (mg/L)	3.237	16.756	0.169	<0.001	3630	217236

Data source: Station 3 - 5 meters in USGS Water Quality

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
SPM (mg/L)	93	0	41.032	30.779	3.192	6.339

Column	Range	Max	Min	Median	25%	75%
SPM (mg/L)	229	236	7	34	23	51

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum of Squares
SPM (mg/L)	3.419	17.678	0.18	<0.001	3816	243736

Data source: Station 3 - 10 meters in USGS Water Quality

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
SPM (mg/L)	89	0	49.539	35.385	3.751	7.454

Column	Range	Max	Min	Median	25%	75%
SPM (mg/L)	244	259	15	39	28.75	58.25

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum of Squares
SPM (mg/L)	3.27	14.913	0.183	<0.001	4409	328601

*SPM - Suspended Particulate Matter

Table 5. Descriptive Statistics Station 4 (Simmons Point):

Data source: Station 4 - 1 meter in USGS Water Quality

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
SPM (mg/L)*	91	0	43.209	33.575	3.52	6.992

Column	Range	Max	Min	Median	25%	75%
SPM (mg/L)	238	246	8	34	24	49.75

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum of Squares
SPM (mg/L)	3.07	14.347	0.197	<0.001	3932	271354

Data source: Station 4 - 5 meters in USGS Water Quality

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
SPM (mg/L)	91	0	44.857	32.828	3.441	6.837

Column	Range	Max	Min	Median	25%	75%
SPM (mg/L)	227	237	10	36	24	54.25

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum of Squares
SPM (mg/L)	2.862	12.548	0.189	<0.001	4082	280100

Data source: Station 4 - 10 meters in USGS Water Quality

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
SPM (mg/L)	90	0	50.511	35.06	3.696	7.343

Column	Range	Max	Min	Median	25%	75%
SPM (mg/L)	232	243	11	39	29	61

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum of Squares
SPM (mg/L)	2.577	9.848	0.185	<0.001	4546	339024

*SPM - Suspended Particulate Matter

Table 6. Descriptive Statistics Station 5 (Middle Ground):

Data source: Station 5 - 1 meter in USGS Water Quality

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
SPM (mg/L)*	73	0	43.233	35.265	4.127	8.228

Column	Range	Max	Min	Median	25%	75%
SPM (mg/L)	233	241	8	32	25	48.75

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum of Squares
SPM (mg/L)	3.066	13.295	0.205	<0.001	3156	225982

Data source: Station 5 - 5 meters in USGS Water Quality

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
SPM (mg/L)	73	0	46.658	36.149	4.231	8.434

Column	Range	Max	Min	Median	25%	75%
SPM (mg/L)	239	250	11	37	26	53

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum of Squares
SPM (mg/L)	2.938	13.095	0.206	<0.001	3406	253004

Data source: Station 5 - 10 meters in USGS Water Quality

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
SPM (mg/L)	72	0	56.056	39.118	4.61	9.192

Column	Range	Max	Min	Median	25%	75%
SPM (mg/L)	233	247	14	46.5	28.5	68

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum of Squares
SPM (mg/L)	2.235	7.363	0.187	<0.001	4036	334888

*SPM - Suspended Particulate Matter

Table 7. Descriptive Statistics Station 6 (Roe Island):

Data source: Station 6 - 1 meter in USGS Water Quality

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
SPM (mg/L)*	74	0	46.297	38.315	4.454	8.877

Column	Range	Max	Min	Median	25%	75%
SPM (mg/L)	254	263	9	35.5	24	54

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum of Squares
SPM (mg/L)	3.009	13.446	0.211	<0.001	3426	265780

Data source: Station 6 - 5 meters in USGS Water Quality

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
SPM (mg/L)	74	0	50.189	38.04	4.422	8.813

Column	Range	Max	Min	Median	25%	75%
SPM (mg/L)	243	252	9	39	25	65

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum of Squares
SPM (mg/L)	2.468	9.879	0.182	<0.001	3714	292038

Data source: Station 6 - 10 meters in USGS Water Quality

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
SPM (mg/L)	68	0	61.426	45.922	5.569	11.116

Column	Range	Max	Min	Median	25%	75%
SPM (mg/L)	253	263	10	48.5	29.5	75

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum of Squares
SPM (mg/L)	2.02	5.312	0.203	<0.001	4177	397873

*SPM - Suspended Particulate Matter

Table 8. Descriptive Statistics Station 9 (Benicia):

Data source: Station 9 - 1 meter in USGS Water Quality

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
SPM (mg/L)*	94	0	49.511	39.746	4.1	8.141

Column	Range	Max	Min	Median	25%	75%
SPM (mg/L)	214	221	7	40.5	22	64

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum of Squares
SPM (mg/L)	1.966	5.043	0.143	<0.001	4654	377340

Data source: Station 9 - 10 meters in USGS Water Quality

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
SPM (mg/L)	96	0	63.625	47.598	4.858	9.644

Column	Range	Max	Min	Median	25%	75%
SPM (mg/L)	217	225	8	56	27	82.5

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum of Squares
SPM (mg/L)	1.357	1.917	0.132	<0.001	6108	603852

Data source: Station 9 - 25 meters in USGS Water Quality

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
SPM (mg/L)	85	0	107.412	83.972	9.108	18.112

Column	Range	Max	Min	Median	25%	75%
SPM (mg/L)	361	370	9	77	47	148

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum of Squares
SPM (mg/L)	1.195	0.878	0.163	<0.001	9130	1572984

*SPM - Suspended Particulate Matter

Table 9. Descriptive Statistics Station 10 (Crockett):

Data source: Station 10 - 1 meter in USGS Water Quality

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
SPM (mg/L)*	94	0	44.798	32.809	3.384	6.72

Column	Range	Max	Min	Median	25%	75%
SPM (mg/L)	158	166	8	36	19	60

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum of Squares
SPM (mg/L)	1.398	2.111	0.131	<0.001	4211	288753

Data source: Station 10 - 10 meters in USGS Water Quality

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
SPM (mg/L)	94	0	61.564	53.414	5.509	10.94

Column	Range	Max	Min	Median	25%	75%
SPM (mg/L)	291	299	8	46.5	22	76

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum of Squares
SPM (mg/L)	1.984	5.126	0.162	<0.001	5787	621601

Data source: Station 10 - 18 meters in USGS Water Quality

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
SPM (mg/L)	67	0	99.642	86.699	10.592	21.148

Column	Range	Max	Min	Median	25%	75%
SPM (mg/L)	450	458	8	73	37.25	121

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum of Squares
SPM (mg/L)	1.716	3.652	0.164	<0.001	6676	1161312

*SPM - Suspended Particulate Matter

Table 10. Descriptive Statistics Station 18 Point Blunt):

Data source: Station 18 - 1 meter in USGS Water Quality

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
SPM (mg/L)*	89	0	12.169	12.167	1.29	2.563

Column	Range	Max	Min	Median	25%	75%
SPM (mg/L)	67	68	1	8	6	13

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum of Squares
SPM (mg/L)	2.97	9.828	0.282	<0.001	1083	26205

Data source: Station 18 - 10 meters in USGS Water Quality

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
SPM (mg/L)	90	0	10.778	9.253	0.975	1.938

Column	Range	Max	Min	Median	25%	75%
SPM (mg/L)	50	50	0	8	5	13

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum of Squares
SPM (mg/L)	2.297	6.184	0.192	<0.001	970	18074

Data source: Station 18 - 25 meters in USGS Water Quality

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
SPM (mg/L)	88	0	14.455	11.982	1.277	2.539

Column	Range	Max	Min	Median	25%	75%
SPM (mg/L)	77	79	2	12	7	18

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum of Squares
SPM (mg/L)	2.686	10.528	0.149	<0.001	1272	30876

*SPM - Suspended Particulate Matter

Table 11. Descriptive Statistics Station 19 (Golden Gate:

Data source: Station 19 - 1 meter in USGS Water Quality

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
SPM (mg/L)*	22	0	8.545	6.307	1.345	2.797

Column	Range	Max	Min	Median	25%	75%
SPM (mg/L)	26	28	2	7	5	10

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum of Squares
SPM (mg/L)	1.813	3.906	0.199	0.024	188	2442

Data source: Station 19 - 10 meters in USGS Water Quality

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
SPM (mg/L)	37	0	8.892	10.421	1.713	3.475

Column	Range	Max	Min	Median	25%	75%
SPM (mg/L)	51	52	1	5	3	9.5

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum of Squares
SPM (mg/L)	2.643	7.933	0.253	<0.001	329	6835

Data source: Station 19 - 20 meters in USGS Water Quality

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
SPM (mg/L)	31	0	9.645	10.537	1.893	3.865

Column	Range	Max	Min	Median	25%	75%
SPM (mg/L)	51	52	1	6	4	11

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum of Squares
SPM (mg/L)	2.673	8.42	0.255	<0.001	299	6215

* SPM - Suspended Particulate Matter

Table 12. Descriptive Statistics Station 20 (Blossom Rock):

Data source: Station 20 - 1 meter in USGS Water Quality

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
SPM (mg/L)*	61	0	11.623	11.689	1.497	2.994

Column	Range	Max	Min	Median	25%	75%
SPM (mg/L)	77	77	0	7	5	15.25

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum of Squares
SPM (mg/L)	3.439	16.274	0.195	<0.001	709	16439

Data source: Station 20 - 10 meters in USGS Water Quality

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
SPM (mg/L)	64	0	12.438	9.13	1.141	2.281

Column	Range	Max	Min	Median	25%	75%
SPM (mg/L)	41	42	1	9.5	6	15.5

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum of Squares
SPM (mg/L)	1.434	1.744	0.215	<0.001	796	15152

Data source: Station 20 - 25 meters in USGS Water Quality

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
SPM (mg/L)	51	0	23.02	22.324	3.126	6.279

Column	Range	Max	Min	Median	25%	75%
SPM (mg/L)	123	124	1	16	9.25	28

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum of Squares
SPM (mg/L)	2.716	9.141	0.176	<0.001	1174	51944

*SPM - Suspended Particulate Matter

3 REFERENCES

The following information was obtained from the USGS Water Resources Website at URL:

http://sfbay.wr.usgs.gov/access/wqdata/index.html

Water quality and nutrient data should be cited from the published USGS Open-File data reports. These are listed below in reverse chronological order. Data collected since 1999 are considered preliminary and unpublished. Permission is necessary for use in a publication, in this case the website itself is cited.

Tide height data are obtained from the NOAA-NOS CO-OPS site. Delta outflow data are obtained from the Interagency Ecological Program DAYFLOW site.

Water Quality Data 1969-1996

1998 data

Arnsberg, A.J., B.E. Cole, and J.E. Cloern. 1998. Studies of the San Francisco Bay, California Estuarine Ecosystem: Regional monitoring program results, 1998: U.S. Geological Survey Open-File Report 01-68, 217 pp.

1997 data

Baylosis, J.I., J.L. Edmunds, B.E. Cole, and J.E. Cloern. 1998. Studies of the San Francisco Bay, California Estuarine Ecosystem: Regional monitoring program results, 1997: U.S. Geological Survey Open-File Report 98-168, 194 pp.

1996 data

Baylosis, J.I., J.L. Edmunds, B.E. Cole, and J.E. Cloern. 1997. Studies of the San Francisco Bay, California Estuarine Ecosystem: Pilot regional monitoring results, 1996: U.S. Geological Survey Open-File Report 97-598, 203 pp.

1995 data

Edmunds, J.L., B.E. Cole, J.E. Cloern, and Dufford, R.G. 1997. Studies of the San Francisco Bay, California, Estuarine Ecosystem. Pilot Regional Monitoring Program Results, 1995: U.S. Geological Survey Open-File Report 97-15, 380 pp.

1994 data

Edmunds, J.L., Cole, B.E., Cloern, J.E., Caffrey, J.M., and Jassby, A.D., 1995, Studies of the San Francisco Bay, California, Estuarine Ecosystem. Pilot Regional Monitoring Program Results, 1994: U.S. Geological Survey Open-File Report 95-378, 436 pp.

1993 data

Caffrey, J.M., Cole, B.E., Cloern, J.E., Rudek, J.R., Tyler, A.C., and Jassby, A.D. 1994. Studies of the plankton and its environment in the San Francisco Bay Estuary, California, Regional Monitoring Results, 1993: U.S. Geological Survey Open-File Report 94-82, 411 p.

1992 data

Wienke, S.M., Cole, B.E. Cloern, J.E., and Alpine, A.E. 1993. Plankton studies in San Francisco Bay. XIV. Chlorophyll distributions and hydrographic properties in San Francisco Bay, 1992: U.S. Geological Survey Open-File Report 93-423, 175 pp.

1991 data

Wienke, S.M., Cole, B.E., Cloern, J.E., and Alpine, A.E. 1992. Plankton studies in San Francisco Bay. XIII. Chlorophyll distributions and hydrographic properties in San Francisco Bay, 1991: U.S. Geological Survey Open-File Report 92-158, 116 pp.

1990 data

Wienke, S.M., B.E. Cole, J.E. Cloern, and A.E. Alpine. 1991. Plankton studies in San Francisco Bay. XII. Chlorophyll distributions and hydrographic properties in San Francisco Bay, 1990: U.S. Geological Survey Open-File Report 91-476. 85 pp.

1988-1989 data

Wienke, S.M., J.E. Cloern, and B.E. Cole. 1990. Plankton studies in San Francisco Bay. XI. Chlorophyll distributions and hydrographic properties in San Francisco Bay, 1988-1989: U.S. Geological Survey Open-File Report 90-562, 212 pp.

1987 data

Wienke, S.M., A.E. Alpine, J.E. Cloern, and B.E. Cole. 1990. Plankton studies in San Francisco Bay. X. Chlorophyll distributions and hydrographic properties in San Francisco Bay: 1987, U.S. Geological Survey Open-File Report 90-145, 50 pp.

1984-1986 data

Alpine, A.E., S.M. Wienke, J.E. Cloern, and B.E. Cole. 1988. Plankton Studies in San Francisco Bay, IX, Chlorophyll distributions and hydrographic properties of South San Francisco Bay, 1984-1986: U.S. Geological Survey Open File Report 88-319, 86 pp.

1983 data

Alpine, A.E., S.M. Wienke, J.E. Cloern, B.E. Cole, and R.L.J. Wong. 1985. Plankton Studies in San Francisco Bay, VIII, Chlorophyll distributions and hydrographic properties of South San Francisco Bay, 1983: U.S. Geological Survey Open File Report 85-196, 58 pp.

1982 data

Unpublished

1981 data

Alpine, A.E., J.E. Cloern, and B.E. Cole. 1981. Plankton Studies in San Francisco Bay 1, chlorophyll distributions and hydrographic properties of the San Francisco Bay estuary, July 1977-December 1979: U.S. Geological Survey Open-File Report 81-213, 150 pp.

1980 data

Dedini, L.A., L.E. Schemel, and M.A. Tembruell. 1982. Salinity and temperature measurements in San Francisco Bay waters, 1980: U.S. Geological Survey Open-File Report 80-1293, 49 pp.

1977- 1979 data

Alpine, A.E., J.E. Cloern, and B.E. Cole. 1981. Plankton Studies in San Francisco Bay 1, chlorophyll distributions and hydrographic properties of the San Francisco Bay estuary, July 1977-December 1979: U.S. Geological Survey Open-File Report 81-213, 150 pp.

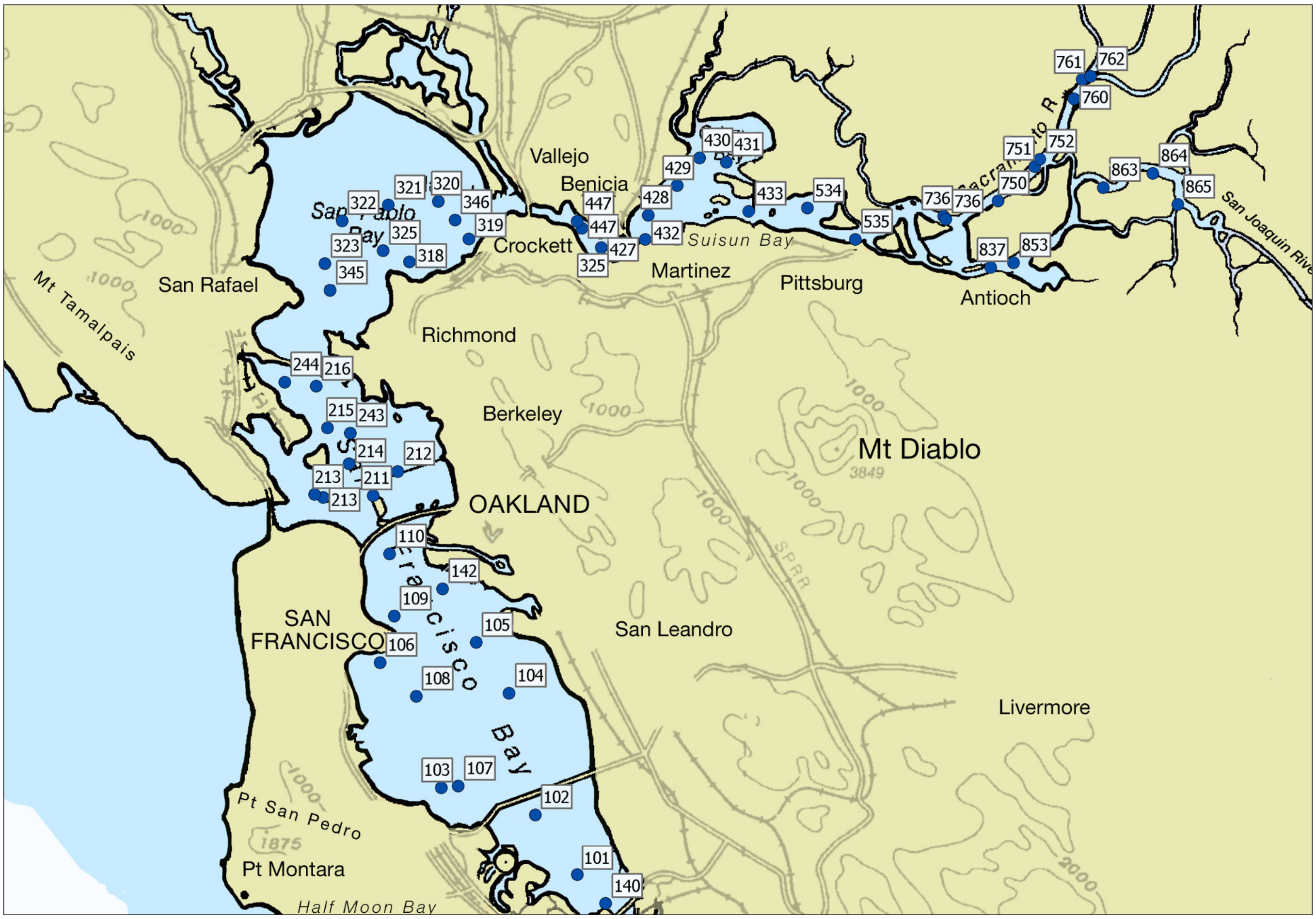
1969-1976 data

Smith, R.E., R.E. Herndon, and D.D. Harmon. 1979. Physical and chemical properties of San Francisco Bay waters, 1969-1976: U.S. Geological Survey Open File Report 79-511, 607 pp.

APPENDIX G

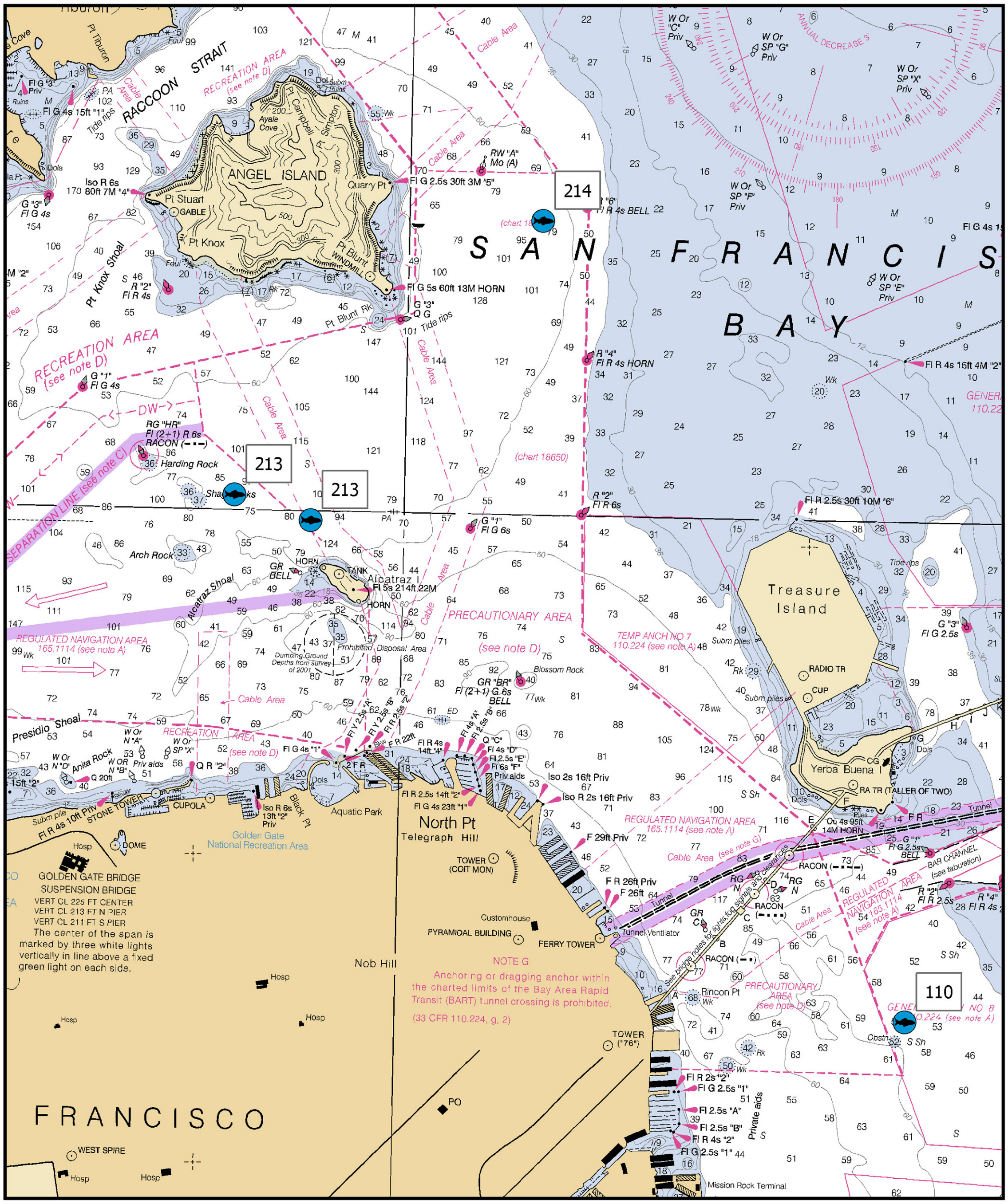
Summary of CDFG 1980-2001 Fishery Data

The California Department of Fish and Game (CDFG) has conducted fishery sampling using a variety of collection techniques, including a midwater trawl, otter trawl, plankton net, and beach seine, to sample fish and macroinvertebrates inhabiting the Bay-Delta estuary since 1980. Fishery sampling is conducted at approximately monthly intervals at sampling sites located throughout San Francisco Bay and the western delta. At several of the sampling sites, such as Station 213 located within Central Bay, two separate sampling locations have been identified for use in collections on ebb and flood tide conditions. The accompanying maps depicting CDFG sampling sites show both ebb and flood tide locations where appropriate. Additional information regarding the CDFG fishery survey program is presented in Section 5 and discussed in detail in Baxter *et al.* (1999).



California Department of Fish and Game Sampling Locations (Baxter *et al.* 1999)

Central Bay



Central Bay
CDFG Sampling Stations

Physical Characteristics

Salinity, Temperature and Depth of Sampling Location Station 213

	Average Salinity (ppt)	Surface Salinity (ppt)	Bottom Salinity (ppt)	Average Temperature (C°)	Average Depth
January	28	26	29	11	77
February	27	24	29	12	75
March	27	23	29	12	76
April	28	25	30	13	75
May	29	27	30	13	71
June	29	28	30	14	75
July	31	30	32	15	76
August	32	31	32	16	76
September	31	30	31	16	76
October	32	31	32	16	78
November	31	31	31	14	76
December	30	28	31	12	72

Salinity, Temperature and Depth of Sampling Location Station 110

	Average Salinity (ppt)	Surface Salinity (ppt)	Bottom Salinity (ppt)	Average Temperature (C°)	Average Depth
January	25	23	26	11	52
February	24	21	26	12	53
March	24	21	27	13	53
April	25	23	27	14	50
May	27	26	28	15	52
June	28	27	29	16	50
July	29	29	30	18	50
August	30	30	30	18	51
September	30	30	30	18	53
October	31	30	31	17	53
November	30	30	30	14	53
December	27	26	28	12	54

Salinity, Temperature and Depth of Sampling Location Station 214

	Average Salinity (ppt)	Surface Salinity (ppt)	Bottom Salinity (ppt)	Average Temperature (C°)	Average Depth
January	27	23	29	11	53
February	25	21	27	11	54
March	23	19	25	12	51
April	24	22	26	13	53
May	27	25	29	14	54
June	29	27	30	15	50
July	30	29	31	16	55
August	30	29	31	17	50
September	30	29	31	17	53
October	31	30	31	16	52
November	30	30	31	14	54
December	29	26	30	12	55

Species Composition - Fish

Station 213 Otter Trawl

Common Name	Percentage
speckled sanddab	22.57%
plainfin midshipman	22.57%
white croaker	9.46%
longfin smelt	9.22%
English sole	8.61%
Pacific staghorn sculpin	6.56%
bay goby	2.59%
curlfin sole	2.04%
Pacific tomcod	2.03%
shiner perch	2.03%
spotted cusk-eel	1.81%
showy snailfish	1.15%
Pacific herring	0.89%
bonehead sculpin	0.83%
brown rockfish	0.83%
brown smoothhound	0.79%
California tonguefish	0.79%
Pacific sand lance	0.74%
sand sole	0.64%
big skate	0.57%
kelp greenling	0.47%
bay pipefish	0.41%
California halibut	0.28%
lingcod	0.24%
yellowfin goby	0.23%
river lamprey	0.15%
Pacific sardine	0.14%
pygmy poacher	0.14%
bat ray	0.13%
spiny dogfish	0.13%
Pacific sanddab	0.10%
starry flounder	0.10%
leopard shark	0.09%
black perch	0.08%
cabezon	0.06%
California lizardfish	0.06%
diamond turbot	0.05%
brown Irish lord	0.04%
cheekspot goby	0.04%
night smelt	0.04%
pile perch	0.04%
whitebait smelt	0.04%
buffalo sculpin	0.03%
green sturgeon	0.03%
Pacific lamprey	0.03%
rubberlip seaperch	0.03%
saddleback gunnel	0.03%
chameleon goby	0.01%
Dover sole	0.01%
hornyhead turbot	0.01%
onespot fringehead	0.01%
Pacific pompano	0.01%
red Irish lord	0.01%
shovelnose guitarfish	0.01%
unidentified snailfish	0.01%
walleye surfperch	0.01%

Station 214 Otter Trawl

Common Name	Percentage
bay goby	25.07%
speckled sanddab	23.82%
white croaker	11.71%
English sole	11.21%
Pacific staghorn sculpin	7.34%
shiner perch	7.03%
plainfin midshipman	5.46%
longfin smelt	3.39%
Pacific tomcod	1.37%
California tonguefish	1.06%
yellowfin goby	0.39%
starry flounder	0.36%
brown smoothhound	0.23%
big skate	0.21%
Pacific herring	0.19%
California halibut	0.17%
bay pipefish	0.17%
Pacific sanddab	0.16%
leopard shark	0.06%
diamond turbot	0.06%
bat ray	0.05%
showy snailfish	0.05%
whitebait smelt	0.05%
black perch	0.04%
brown rockfish	0.04%
curlfin sole	0.04%
lingcod	0.04%
pygmy poacher	0.02%
spiny dogfish	0.02%
walleye surfperch	0.02%
white seaperch	0.02%
white sturgeon	0.02%
pile perch	0.01%
sand sole	0.01%
jacksmelt	0.01%
Pacific sardine	0.01%
barred surfperch	0.01%
cheekspot goby	0.01%
topsmelt	0.01%
chinook salmon	0.01%
Pacific lamprey	0.01%
river lamprey	0.01%
threadfin shad	0.01%
American shad	0.00%
green sturgeon	0.00%
hybrid sole	0.00%
Pacific pompano	0.00%
saddleback gunnel	0.00%
spotted cusk-eel	0.00%

Station 110 Otter Trawl

Common Name	Percentage
white croaker	21.18%
bay goby	19.26%
plainfin midshipman	15.26%
longfin smelt	13.36%
shiner perch	8.72%
speckled sanddab	7.28%
English sole	4.02%
Pacific staghorn sculpin	3.55%
Pacific tomcod	1.60%
yellowfin goby	0.99%
brown smoothhound	0.88%
California tonguefish	0.50%
brown rockfish	0.43%
bay pipefish	0.40%
California halibut	0.38%
showy snailfish	0.35%
Pacific herring	0.24%
leopard shark	0.21%
big skate	0.18%
bat ray	0.17%
bonehead sculpin	0.10%
sand sole	0.10%
cheekspot goby	0.07%
diamond turbot	0.07%
chameleon goby	0.07%
lingcod	0.06%
starry flounder	0.06%
curlfin sole	0.05%
pile perch	0.04%
arrow goby	0.04%
black perch	0.03%
Pacific lamprey	0.03%
Pacific sardine	0.03%
river lamprey	0.03%
spotted cusk-eel	0.03%
walleye surfperch	0.03%
jacksmelt	0.02%
striped bass	0.02%
threadfin shad	0.02%
unidentified rockfish	0.02%
green sturgeon	0.01%
hornyhead turbot	0.01%
night smelt	0.01%
Pacific pompano	0.01%
Pacific sanddab	0.01%
pygmy poacher	0.01%
spotfin surfperch	0.01%
surf smelt	0.01%
white seaperch	0.01%
whitebait smelt	0.01%

Station 214 Midwater Trawl

Common Name	Percentage
northern anchovy	92.94%
Pacific herring	4.85%
white croaker	0.71%
jacksmelt	0.34%
Pacific pompano	0.32%
longfin smelt	0.32%
shiner perch	0.18%
Pacific sardine	0.12%
plainfin midshipman	0.05%
bay goby	0.04%
topsmelt	0.03%
chinook salmon	0.03%
English sole	0.01%
American shad	0.01%
surf smelt	0.01%
speckled sanddab	0.01%
bat ray	0.00%
Pacific staghorn sculpin	0.00%
striped bass	0.00%
whitebait smelt	0.00%
night smelt	0.00%
brown smoothhound	0.00%
threadfin shad	0.00%
walleye surfperch	0.00%
big skate	0.00%
black rockfish	0.00%
Pacific tomcod	0.00%
threespine stickleback	0.00%
California halibut	0.00%
white seaperch	0.00%
yellowfin goby	0.00%
bay pipefish	0.00%
kelp greenling	0.00%
lingcod	0.00%
Pacific lamprey	0.00%
Pacific sanddab	0.00%
river lamprey	0.00%
starry flounder	0.00%
steelhead trout	0.00%

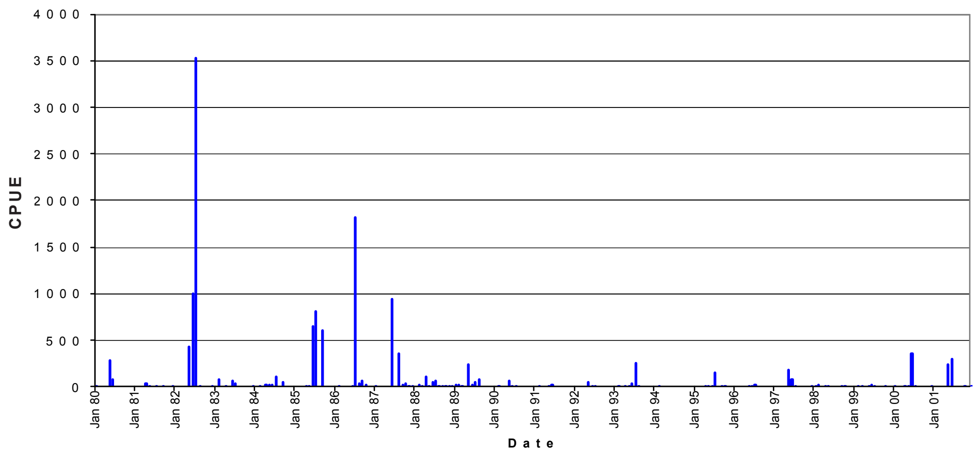
Station 213 Midwater Trawl

Common Name	Percentage 213
northern anchovy	94.21%
Pacific herring	4.74%
jacksmelt	0.22%
Pacific sardine	0.21%
plainfin midshipman	0.17%
Pacific pompano	0.13%
white croaker	0.10%
longfin smelt	0.09%
chinook salmon	0.07%
bay goby	0.02%
whitebait smelt	0.01%
shiner perch	0.01%
English sole	0.01%
speckled sanddab	0.00%
bat ray	0.00%
American shad	0.00%
topsmelt	0.00%
lingcod	0.00%
threespine stickleback	0.00%
brown smoothhound	0.00%
night smelt	0.00%
Pacific staghorn sculpin	0.00%
walleye surfperch	0.00%
black rockfish	0.00%
California grunion	0.00%
Pacific barracuda	0.00%
Pacific electric ray	0.00%
silver surfperch	0.00%
starry flounder	0.00%
steelhead trout	0.00%
striped bass	0.00%
surf smelt	0.00%
threadfin shad	0.00%

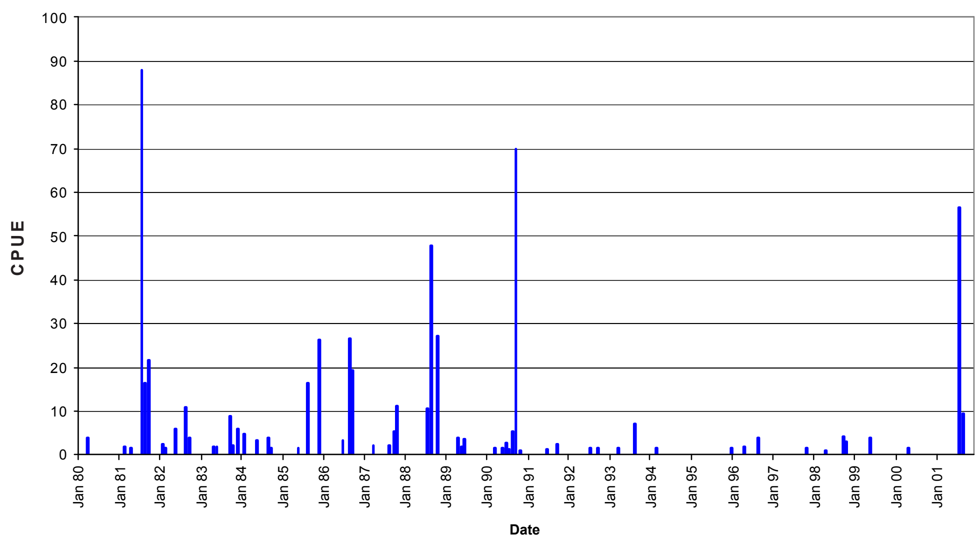
Station 110 Midwater Trawl

Common Name	Percentage
northern anchovy	94.38%
Pacific herring	3.36%
white croaker	0.66%
jacksmelt	0.39%
Pacific sardine	0.38%
plainfin midshipman	0.22%
longfin smelt	0.21%
shiner perch	0.11%
topsmelt	0.08%
Pacific pompano	0.06%
bay goby	0.06%
English sole	0.01%
American shad	0.01%
bat ray	0.01%
chinook salmon	0.01%
whitebait smelt	0.01%
Pacific staghorn sculpin	0.01%
night smelt	0.00%
striped bass	0.00%
speckled sanddab	0.00%
threadfin shad	0.00%
Pacific tomcod	0.00%
yellowfin goby	0.00%
brown smoothhound	0.00%
queenfish	0.00%
big skate	0.00%
brown rockfish	0.00%
river lamprey	0.00%
California lizardfish	0.00%
leopard shark	0.00%
lingcod	0.00%
sand sole	0.00%
starry flounder	0.00%
surf smelt	0.00%
thresher shark	0.00%
walleye surfperch	0.00%

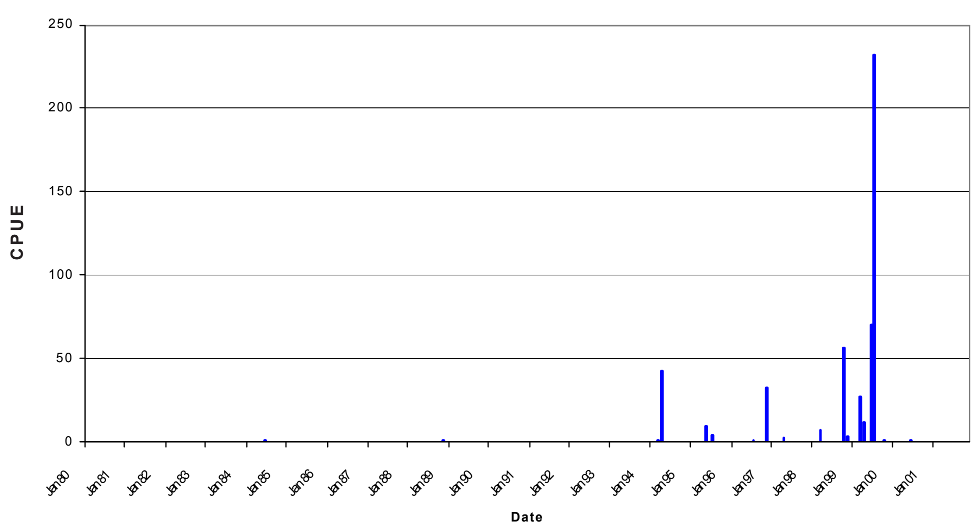
C.P.U.E. of Pacific Herring
Station 213 Midwater Trawl



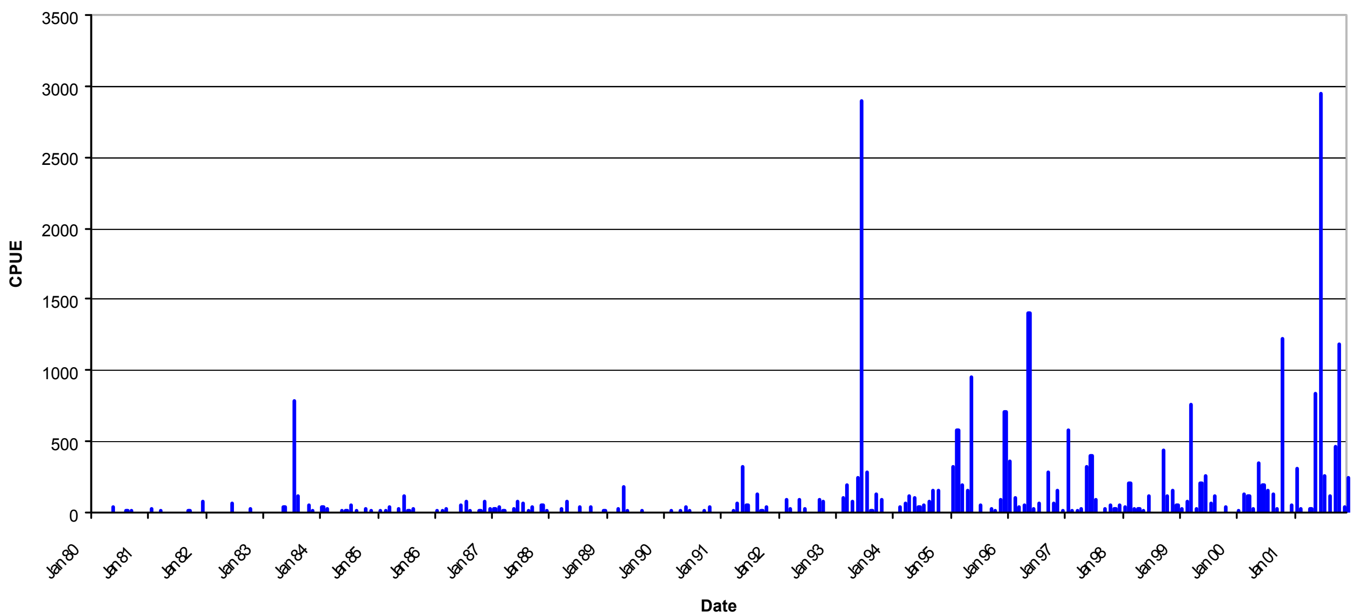
C.P.U.E. of Jacksmelt
Station 213 Midwater Trawl



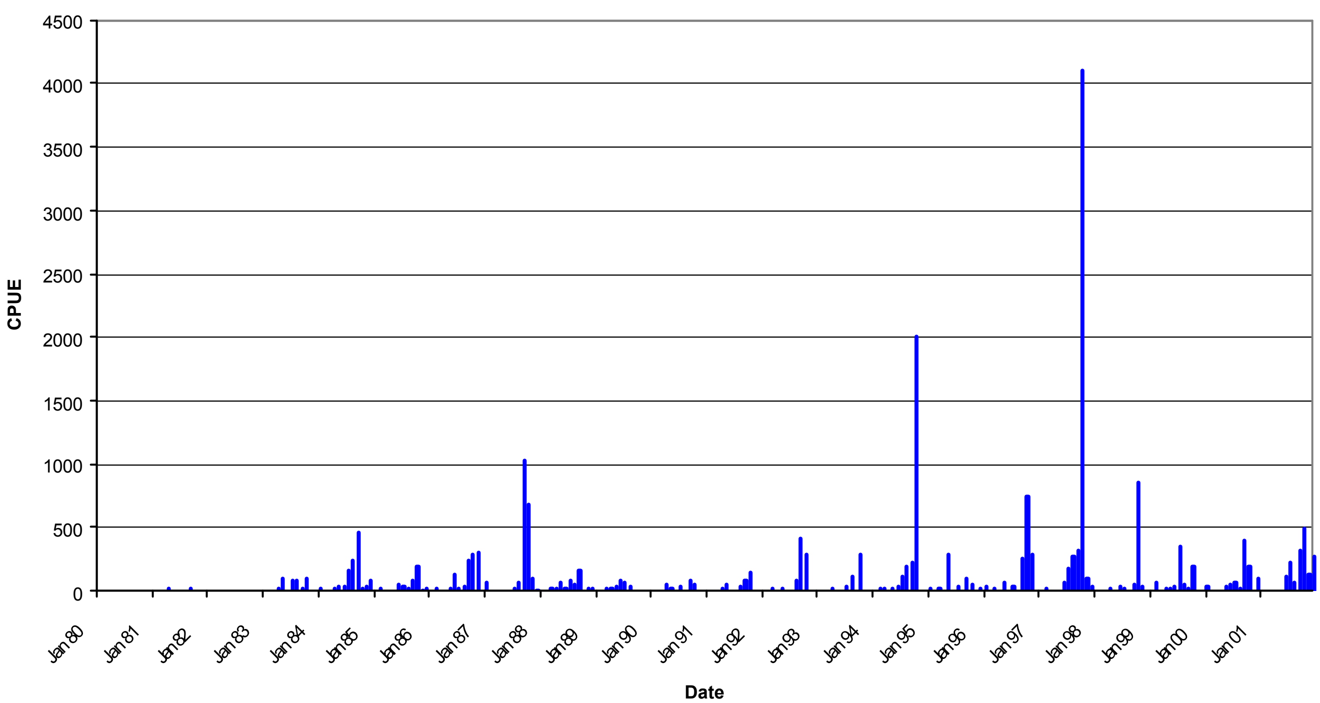
C.P.U.E. of Pacific Sardine
Station 213 Midwater Trawl

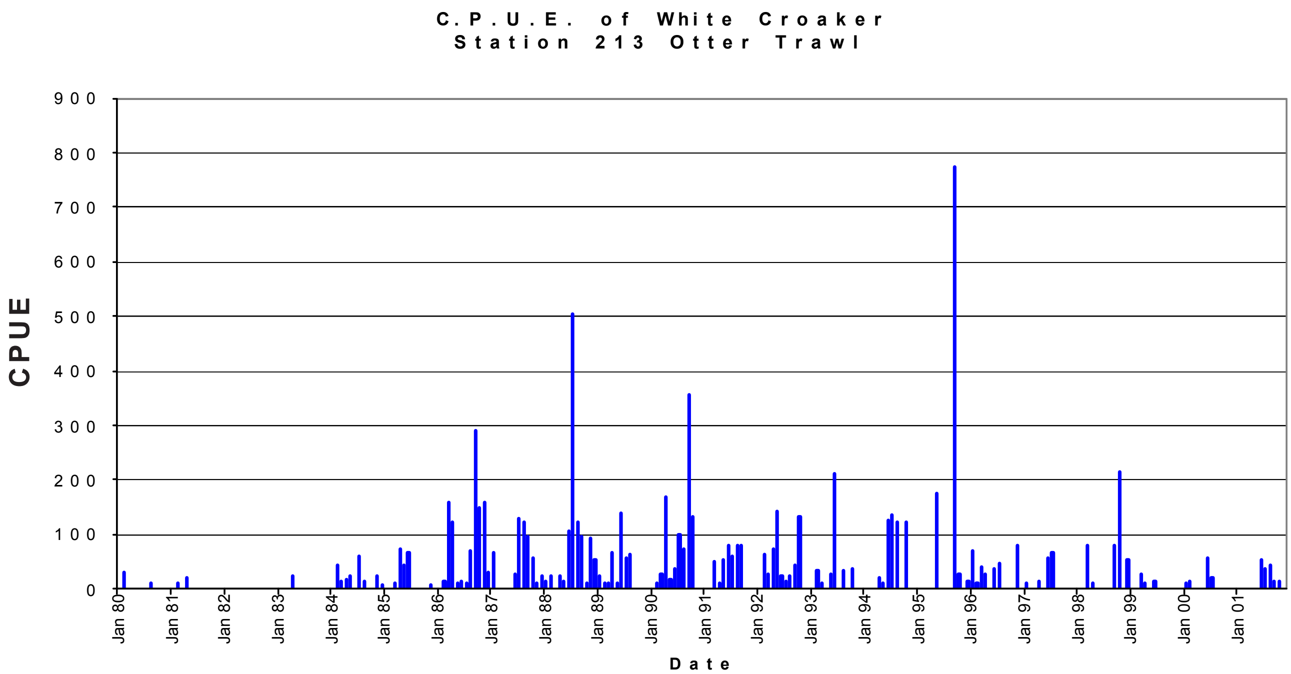


C.P.U.E. of Speckled Sanddab
Station 213 Otter Trawl



C.P.U.E. of Plainfin midshipman
Station 213 Otter Trawl





Species Compositions - Crab

Station 213 Otter Trawl

Common Name	Percentage 213
Dungeness crab	70.33%
graceful rock crab	12.59%
red rock crab	10.70%
Pacific rock crab	5.26%
Chinese mitten crab	0.95%
yellow rock crab	0.18%

Station 110 Otter Trawl

Common Name	Percentage 110
graceful rock crab	69.82%
Dungeness crab	16.74%
Pacific rock crab	8.79%
red rock crab	4.06%
yellow rock crab	0.59%

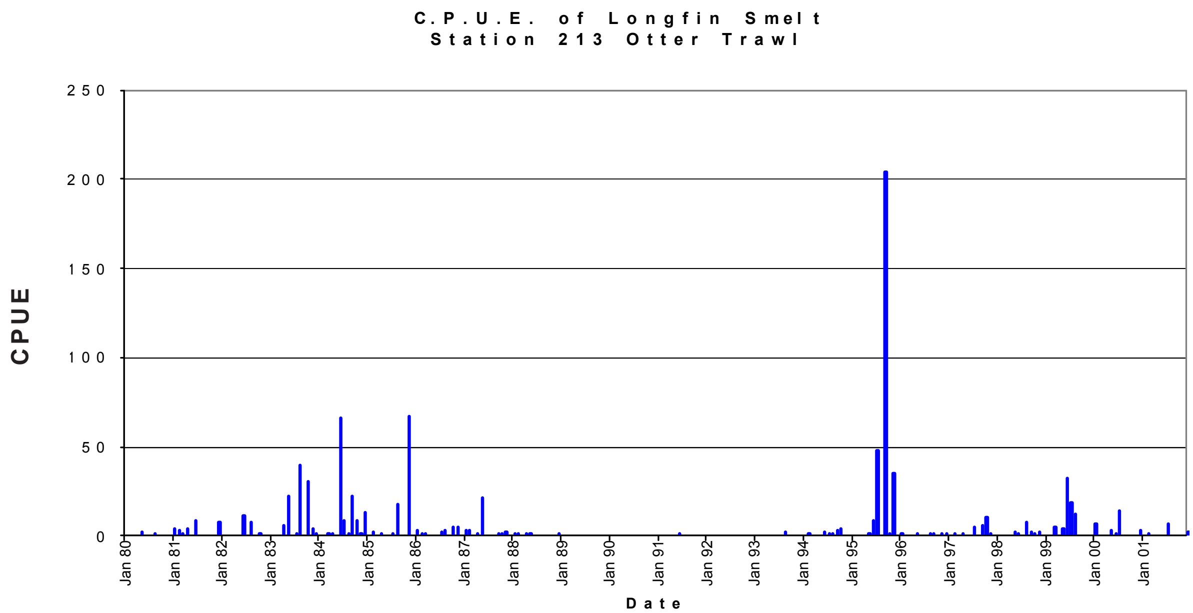
Station 214 Otter Trawl

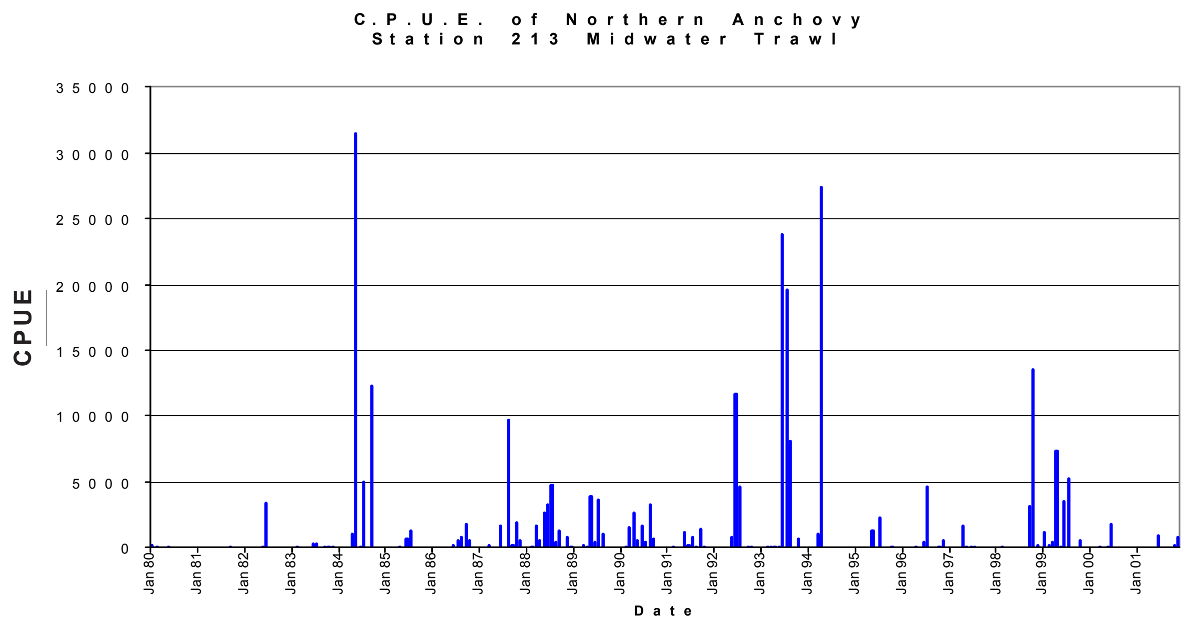
Common Name	Percentage 214
Dungeness crab	29.08%
graceful rock crab	67.48%
Pacific rock crab	1.78%
red rock crab	1.33%
yellow rock crab	0.33%

Species Composition – Shrimp

Station 213 Otter Trawl

Common Name	Percentage 213
blacktail bay shrimp	73.84%
California bay shrimp	12.42%
smooth bay shrimp	8.79%
Stimpson coastal shrimp	3.61%
blackspotted bay shrimp	1.33%
dock shrimp	0.01%
oriental shrimp	0.00%
visored shrimp	0.00%
red rock shrimp	0.00%





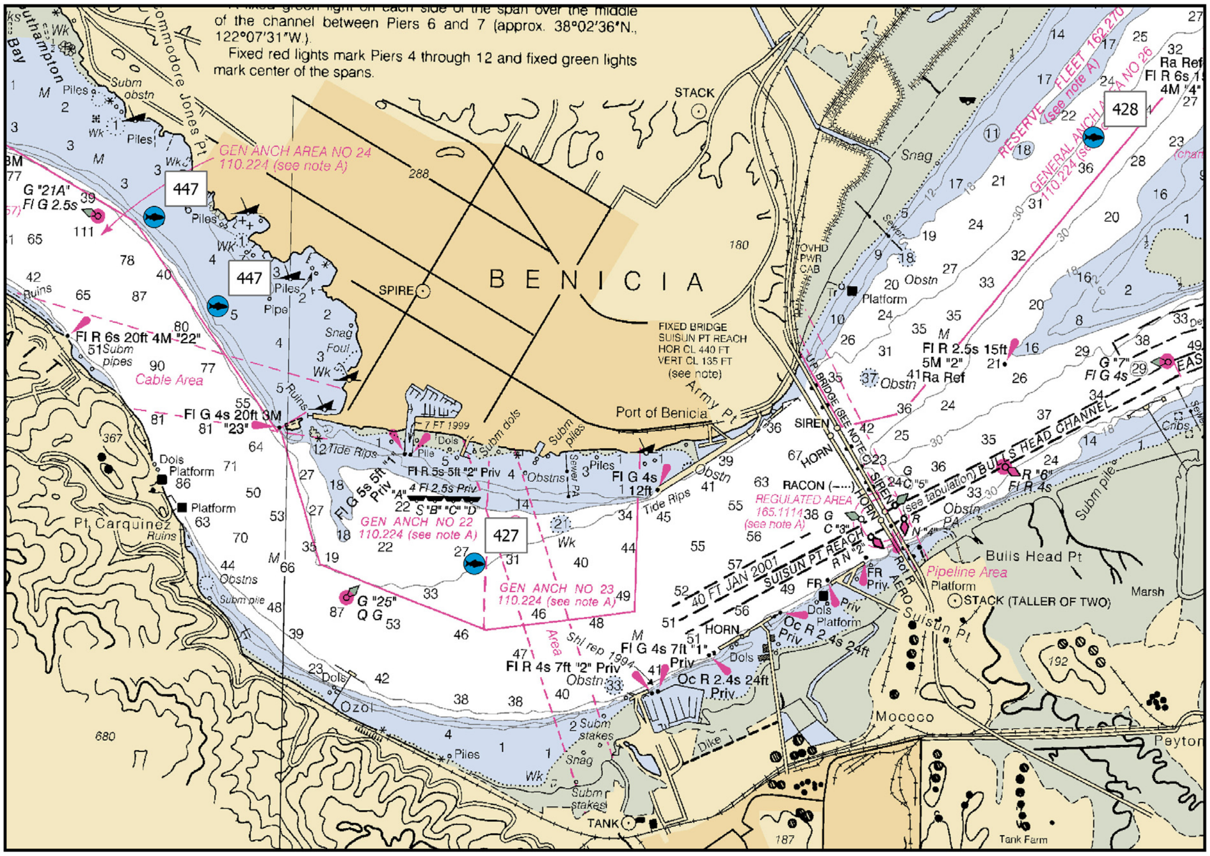
Station 214 Otter Trawl

Common Name	Percentage 214
blackspotted bay shrimp	44.33%
blacktail bay shrimp	23.13%
California bay shrimp	23.06%
Stimpson coastal shrimp	9.16%
smooth bay shrimp	0.31%
dock shrimp	0.00%
oriental shrimp	0.00%
redbanded clear shrimp	0.00%
unidentified Crangon	0.00%
unidentified Heptacarpus	0.00%

Station 110 Otter Trawl

Common Name	Percentage 110
blacktail bay shrimp	51.82%
blackspotted bay shrimp	23.95%
California bay shrimp	13.79%
Stimpson coastal shrimp	9.97%
smooth bay shrimp	0.44%
oriental shrimp	0.02%
dock shrimp	0.00%
miniature spinyhead	0.00%
unidentified Beteaus	0.00%
visored shrimp	0.00%

Carquinez Strait



Carquinez Strait
CDFG Sampling Stations

Physical Characteristics

Salinity, Temperature and Depth of Sampling Location
Station 427

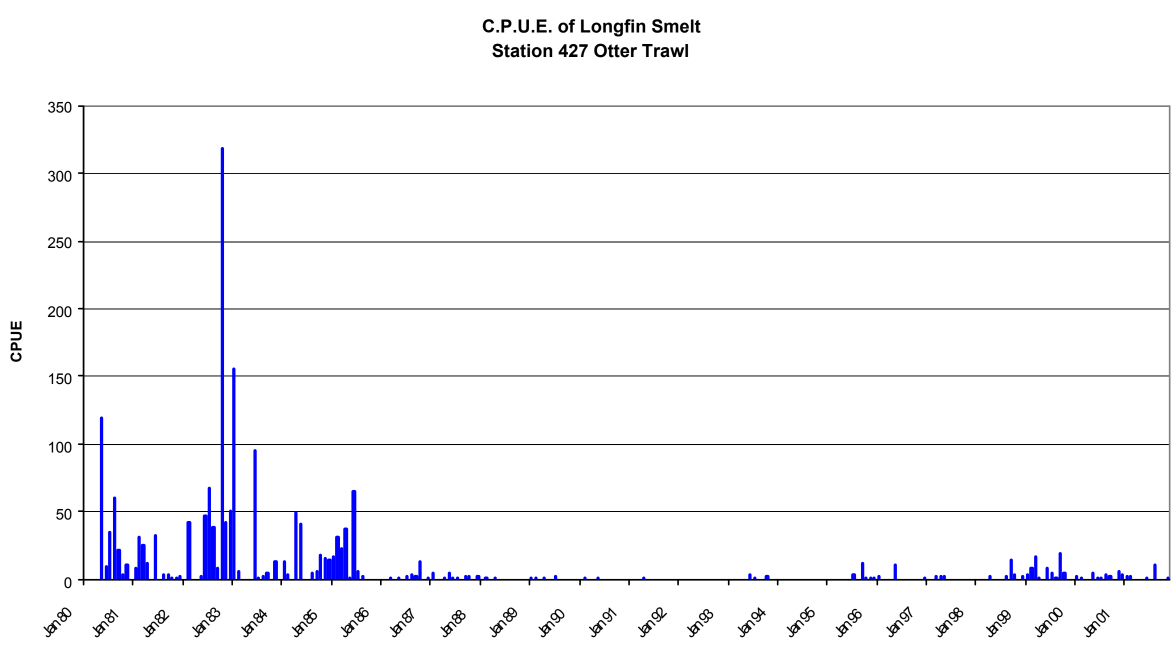
	Average Salinity (ppt)	Surface Salinity (ppt)	Bottom Salinity (ppt)	Average Temperature (C°)	Average Depth
January	13	10	14	9	31
February	9	7	10	10	28
March	7	6	8	12	28
April	6	5	7	15	28
May	10	8	10	17	26
June	11	9	13	19	27
July	14	12	15	20	28
August	15	12	16	20	28
September	15	13	16	20	27
October	17	14	18	19	27
November	18	16	18	16	29
December	16	12	17	12	28

Salinity, Temperature and Depth of Sampling Location Station 447

	Average Salinity (ppt)	Surface Salinity (ppt)	Bottom Salinity (ppt)	Average Temperature (C°)	Average Depth
January	15	14	15	9	12
February	11	10	11	10	12
March	9	8	9	12	9
April	7	7	7	15	10
May	11	10	11	17	9
June	10	10	11	18	10
July	15	14	16	20	10
August	15	14	15	20	10
September	16	15	16	20	10
October	18	18	19	19	10
November	19	18	19	15	12
December	17	17	18	13	11

Salinity, Temperature and Depth of Sampling Location Station 428

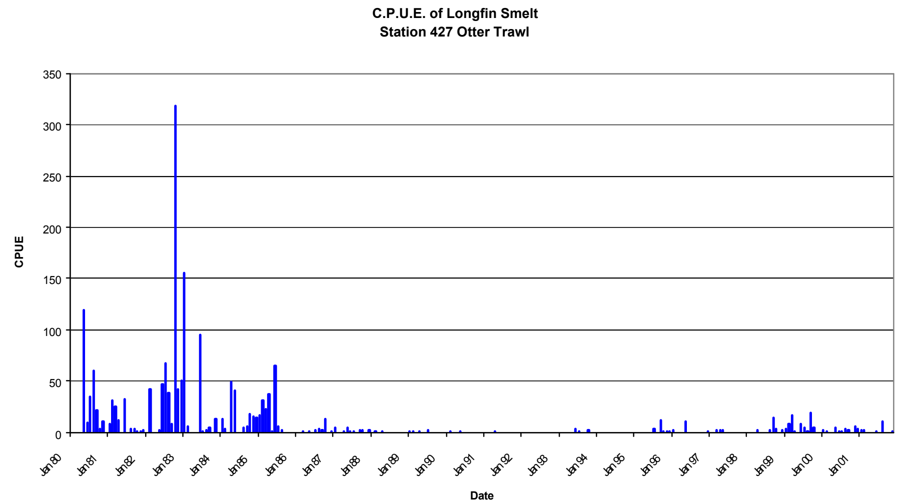
	Average Salinity (ppt)	Surface Salinity (ppt)	Bottom Salinity (ppt)	Average Temperature (C°)	Average Depth
January	12	9	13	9	34
February	9	6	10	10	35
March	6	5	7	12	34
April	5	4	6	15	33
May	9	6	10	17	33
June	10	8	11	19	33
July	12	10	13	20	33
August	11	10	13	20	33
September	12	10	13	20	34
October	14	11	15	19	34
November	16	14	17	16	34
December	12	10	13	12	35

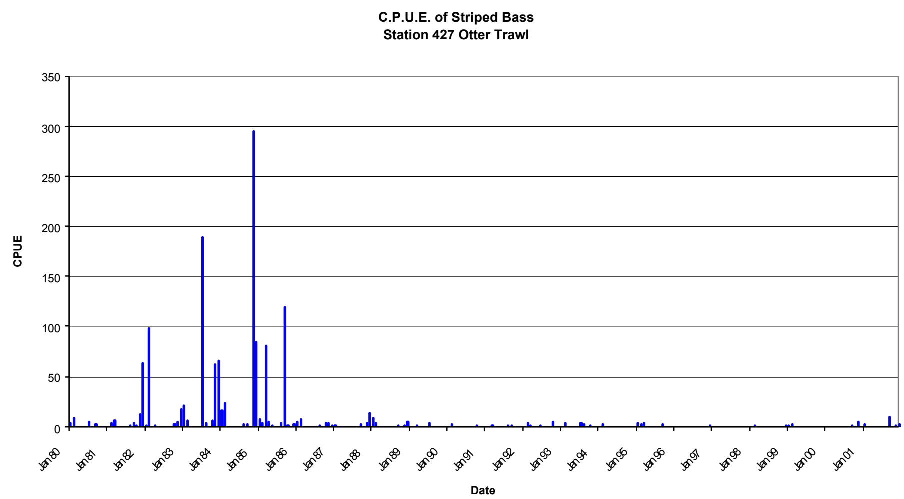


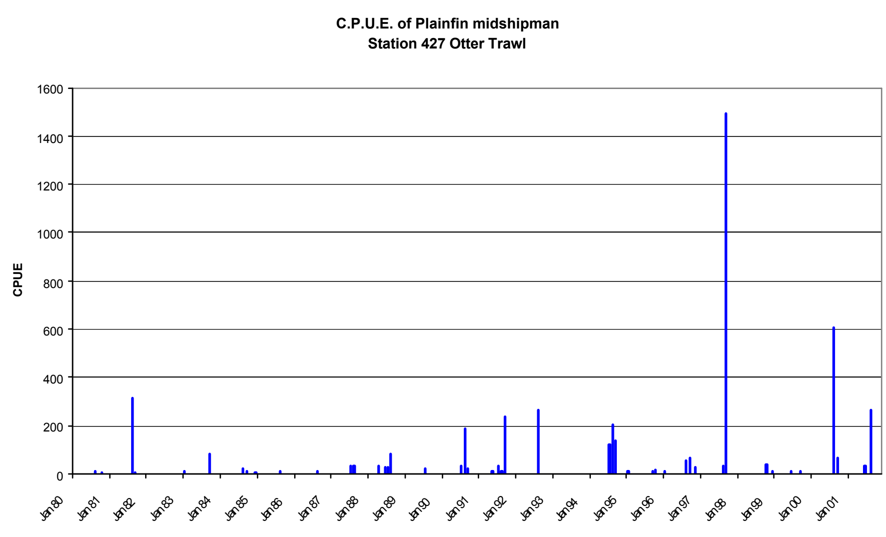
Species Composition - Fish

Station 427 Otter Trawl

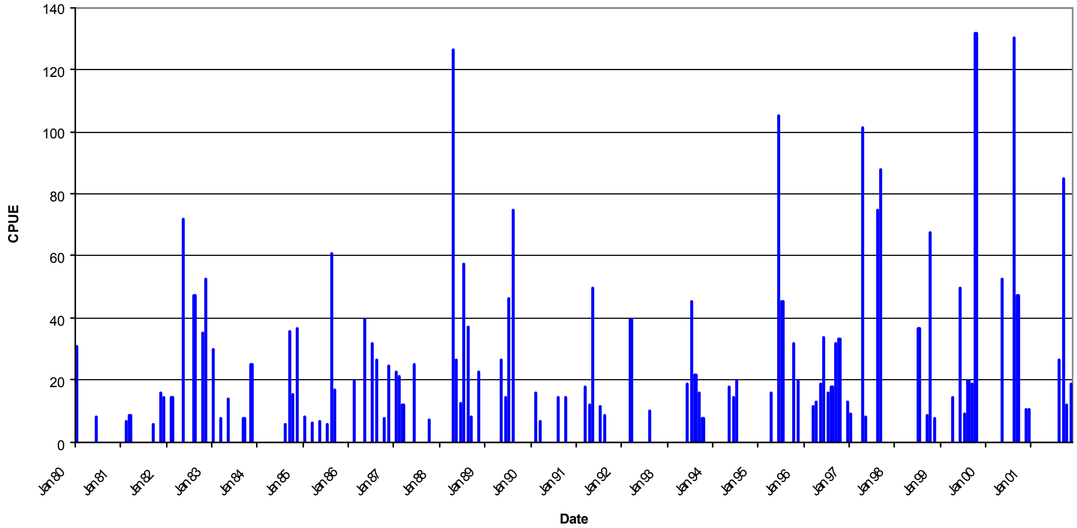
Common Name	Percentage
longfin smelt	35.70%
striped bass	23.10%
plainfin midshipman	13.04%
Pacific staghorn sculpin	10.22%
yellowfin goby	6.22%
bay goby	2.24%
starry flounder	2.07%
speckled sanddab	1.43%
white croaker	0.92%
delta smelt	0.75%
English sole	0.75%
river lamprey	0.44%
white sturgeon	0.37%
brown smoothhound	0.34%
Pacific herring	0.27%
shimofuri goby	0.24%
California halibut	0.20%
chinook salmon	0.20%
sand sole	0.20%
bearded goby	0.17%
Pacific lamprey	0.17%
threespine stickleback	0.17%
American shad	0.14%
splittail	0.14%
threadfin shad	0.07%
big skate	0.03%
black perch	0.03%
California tonguefish	0.03%
chameleon goby	0.03%
channel catfish	0.03%
cheekspot goby	0.03%
green sturgeon	0.03%
Pacific sanddab	0.03%
Pacific tomcod	0.03%
prickly sculpin	0.03%
tule perch	0.03%
unidentified flounder	0.03%
unidentified minnow	0.03%



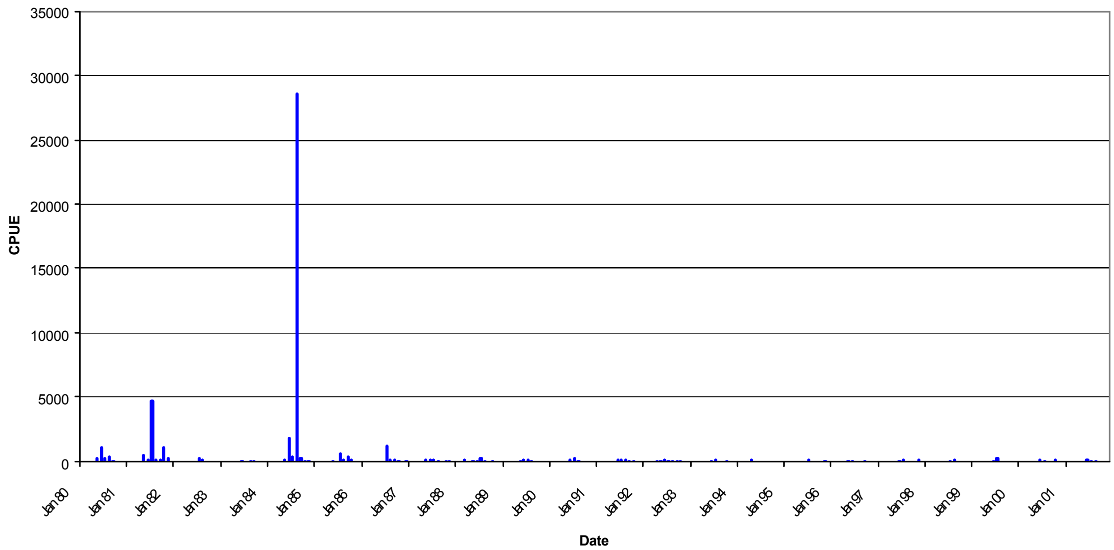




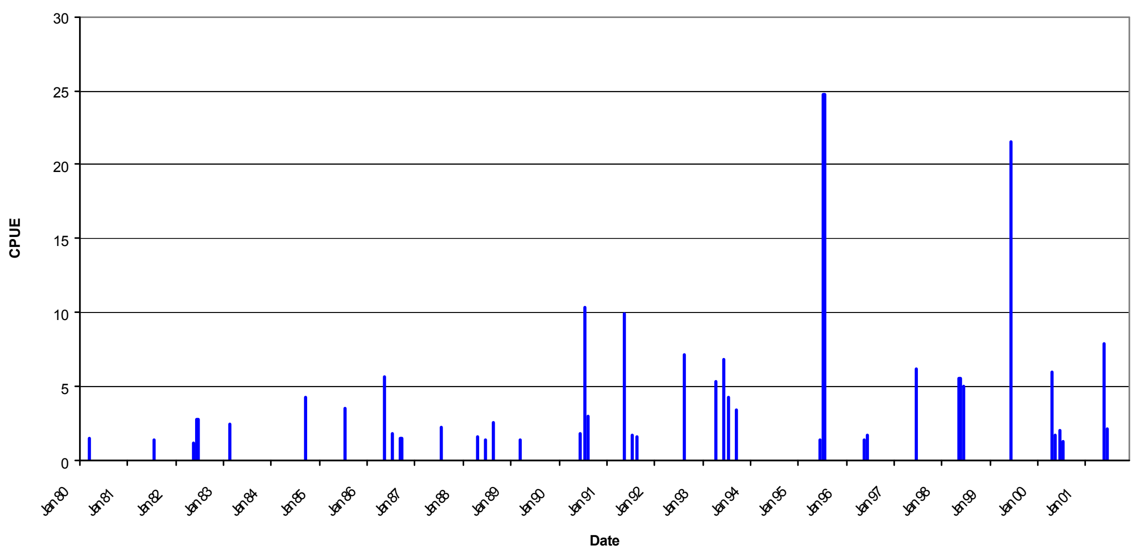
C.P.U.E. of Pacific Staghorn Sculpin
Station 427 Otter Trawl



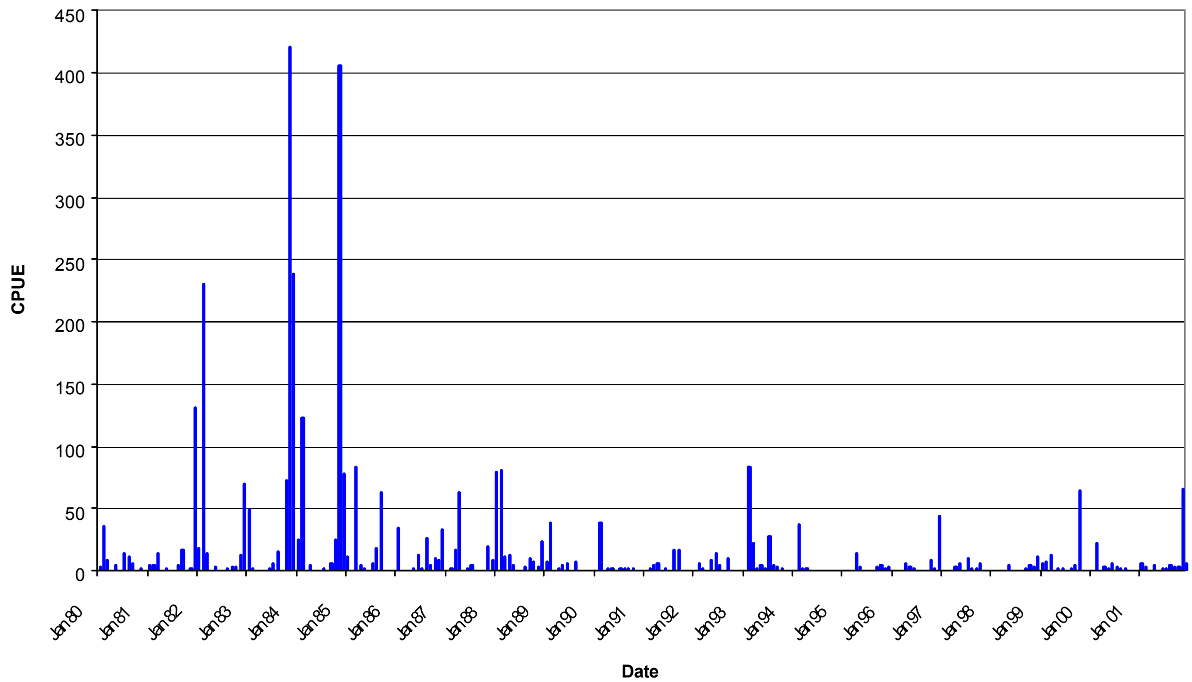
C.P.U.E. of Northern Anchovy
Station 427 Midwater Trawl



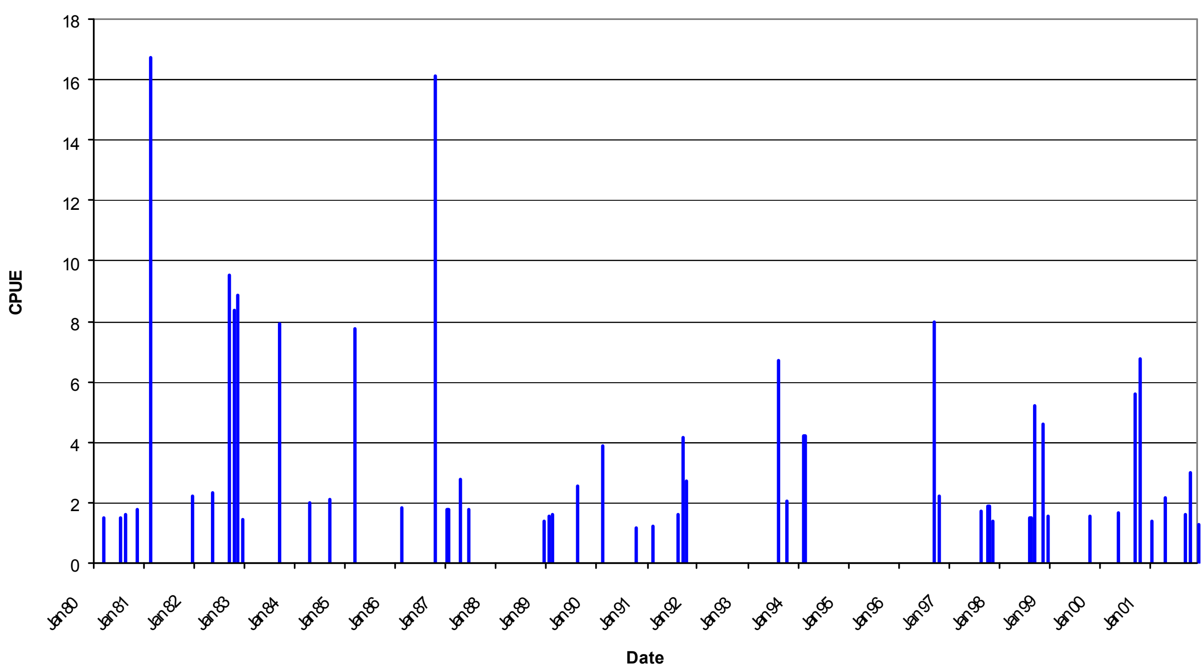
C.P.U.E. of Chinook Salmon
Station 427 Midwater Trawl



C.P.U.E. of Striped Bass
Station 427 Midwater Trawl



C.P.U.E. of American Shad
Station 427 Midwater Trawl



Station 428 Otter Trawl

Common Name	Percentage
longfin smelt	48.79%
striped bass	16.52%
Pacific staghorn sculpin	11.59%
yellowfin goby	8.31%
bay goby	3.79%
plainfin midshipman	1.78%
bearded goby	1.29%
starry flounder	1.26%
delta smelt	0.93%
river lamprey	0.85%
white croaker	0.85%
chameleon goby	0.65%
Pacific lamprey	0.59%
shimofuri goby	0.57%
white sturgeon	0.36%
English sole	0.31%
speckled sanddab	0.28%
threespine stickleback	0.23%
prickly sculpin	0.18%
white catfish	0.15%
Pacific herring	0.10%
splittail	0.10%
American shad	0.08%
California halibut	0.05%
cheekspot goby	0.05%
chinook salmon	0.05%
green sturgeon	0.05%
Pacific tomcod	0.05%
shiner perch	0.05%
brown smoothhound	0.03%
California tonguefish	0.03%
sand sole	0.03%
topsmelt	0.03%

Station 447 Otter Trawl

Common Name	Percentage
striped bass	29.08%
yellowfin goby	19.66%
Pacific staghorn sculpin	18.86%
English sole	9.83%
starry flounder	5.33%
speckled sanddab	4.55%
plainfin midshipman	3.62%
longfin smelt	2.92%
bay goby	1.40%
shiner perch	1.06%
splittail	0.62%
shimofuri goby	0.47%
bearded goby	0.39%
American shad	0.31%
California halibut	0.26%
chameleon goby	0.23%
threadfin shad	0.23%
white croaker	0.21%
white sturgeon	0.21%
Pacific herring	0.16%
chinook salmon	0.13%
green sturgeon	0.13%
California tonguefish	0.08%
prickly sculpin	0.05%
threespine stickleback	0.05%
black perch	0.03%
brown smoothhound	0.03%
delta smelt	0.03%
diamond turbot	0.03%
Pacific tomcod	0.03%
sand sole	0.03%

Stations 427 Midwater Trawl

Common Name	Percentage
northern anchovy	74.34%
longfin smelt	16.17%
striped bass	5.89%
plainfin midshipman	0.72%
yellowfin goby	0.69%
Pacific herring	0.54%
chinook salmon	0.37%
American shad	0.35%
Pacific staghorn sculpin	0.17%
white croaker	0.17%
delta smelt	0.16%
splittail	0.11%
threadfin shad	0.06%
white sturgeon	0.06%
starry flounder	0.05%
threespine stickleback	0.04%
shiner perch	0.03%
English sole	0.02%
jacksmelt	0.01%
shimofuri goby	0.01%
steelhead trout	0.01%
bay goby	0.00%
brown smoothhound	0.00%
California halibut	0.00%
chameleon goby	0.00%
Pacific lamprey	0.00%
Pacific pompano	0.00%
speckled sanddab	0.00%
surf smelt	0.00%

Stations 428 Midwater Trawl

Common Name	Percentage
northern anchovy	50.01%
longfin smelt	33.67%
striped bass	9.47%
Pacific herring	1.87%
yellowfin goby	1.22%
American shad	0.80%
chinook salmon	0.72%
white croaker	0.50%
plainfin midshipman	0.48%
delta smelt	0.42%
Pacific staghorn sculpin	0.20%
starry flounder	0.19%
splittail	0.15%
white sturgeon	0.10%
shimofuri goby	0.04%
threadfin shad	0.04%
jacksmelt	0.02%
threespine stickleback	0.02%
chameleon goby	0.01%
bay goby	0.01%
common carp	0.01%
Pacific lamprey	0.01%
Pacific pompano	0.01%
river lamprey	0.01%
shiner perch	0.01%
speckled sanddab	0.01%
steelhead trout	0.01%
surf smelt	0.01%

Station 447 Midwater Trawl

Common Name	Percentage
northern anchovy	56.77%
chinook salmon	10.83%
striped bass	10.19%
American shad	4.93%
splittail	4.11%
longfin smelt	3.62%
Pacific herring	2.72%
yellowfin goby	1.64%
threadfin shad	1.08%
starry flounder	0.87%
Pacific staghorn sculpin	0.82%
plainfin midshipman	0.51%
jacksmelt	0.36%
white croaker	0.31%
shiner perch	0.21%
English sole	0.15%
shimofuri goby	0.15%
threespine stickleback	0.15%
green sturgeon	0.10%
night smelt	0.10%
prickly sculpin	0.08%
white sturgeon	0.08%
delta smelt	0.05%
steelhead trout	0.05%
bluegill	0.03%
diamond turbot	0.03%
hardhead	0.03%
white seaperch	0.03%

Species Composition - Crab

Station 427 Otter Trawl

Common Name	Percentage 427
Dungeness crab	80.65%
Chinese mitten crab	19.35%

Station 447 Otter Trawl

Common Name	Percentage 447
Dungeness crab	56.77%
Chinese mitten crab	43.23%

Station 428 Otter Trawl

Common Name	Percentage 428
Dungeness crab	79.67%
Chinese mitten crab	19.92%
arched swimming crab	0.41%

Species Composition – Shrimp

Station 427 Otter Trawl

Common Name	Percentage 427
California bay shrimp	94.21%
oriental shrimp	4.35%
blacktail bay shrimp	1.44%
blackspotted bay shrimp	0.00%
Stimpson coastal shrimp	0.00%

Station 447 Otter Trawl

Common Name	Percentage 447
California bay shrimp	85.06%
blacktail bay shrimp	14.30%
oriental shrimp	0.64%

Station 428 Otter Trawl

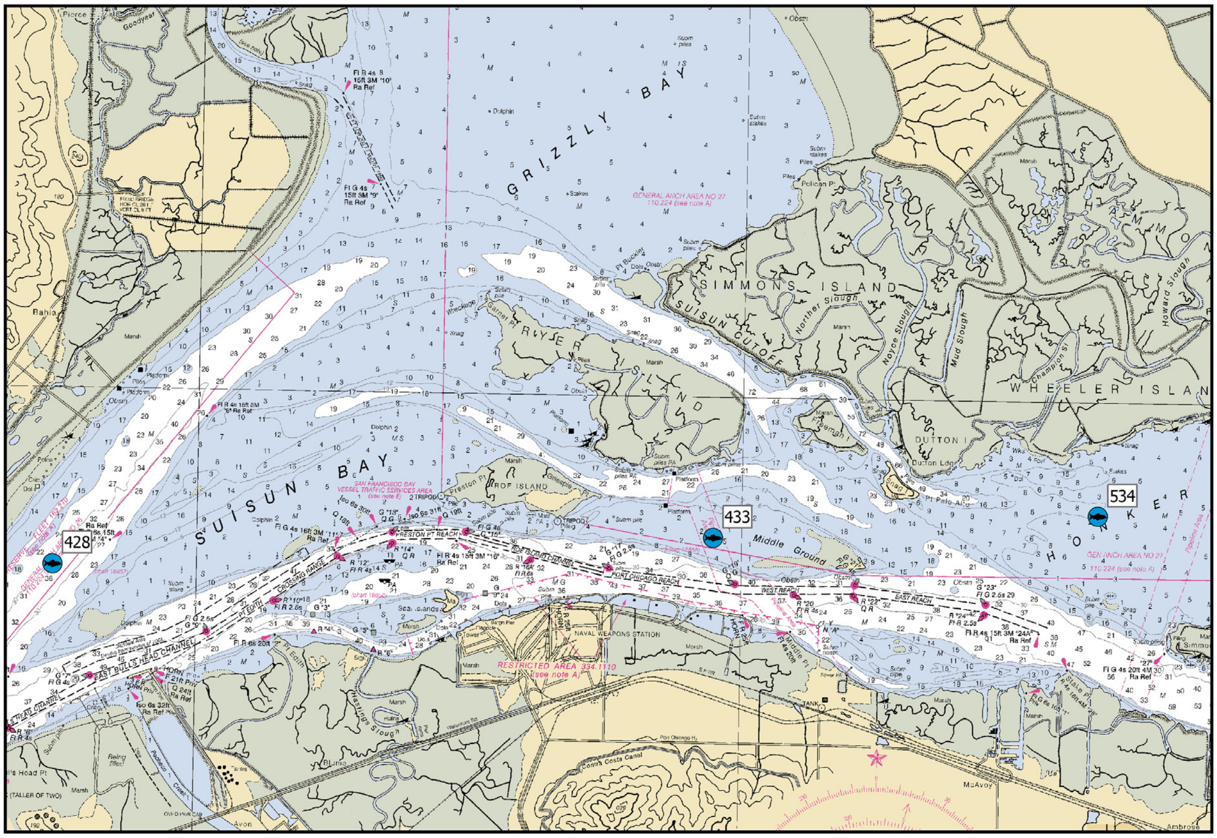
Common Name	Percentage 428
California bay shrimp	92.16%
oriental shrimp	4.17%
blacktail bay shrimp	3.67%
Stimpson coastal shrimp	0.00%
blackspotted bay shrimp	0.00%

Middle Ground Shoal

Physical Characteristics

Salinity, Temperature and Depth of Sampling Location Station 433

	Average Salinity (ppt)	Surface Salinity (ppt)	Bottom Salinity (ppt)	Average Temperature (C°)	Average Depth
January	6	5	7	9	37
February	4	3	4	10	37
March	3	2	3	12	38
April	3	1	3	15	37
May	5	3	5	17	35
June	4	3	4	19	36
July	5	4	5	21	35
August	4	4	5	21	35
September	6	5	7	21	35
October	8	6	9	19	36
November	7	6	8	16	37
December	5	4	6	12	36



CDFG Sampling Stations
Middle Ground Shoal

Salinity, Temperature and Depth of Sampling Location Station 428

	Average Salinity (ppt)	Surface Salinity (ppt)	Bottom Salinity (ppt)	Average Temperature (C°)	Average Depth
January	12	9	13	9	34
February	9	6	10	10	35
March	6	5	7	12	34
April	5	4	6	15	33
May	9	6	10	17	33
June	10	8	11	19	33
July	12	10	13	20	33
August	11	10	13	20	33
September	12	10	13	20	34
October	14	11	15	19	34
November	16	14	17	16	34
December	12	10	13	12	35

Salinity, Temperature and Depth of Sampling Location Station 534

	Average Salinity (ppt)	Surface Salinity (ppt)	Bottom Salinity (ppt)	Average Temperature (C°)	Average Depth
January	5	4	5	8	10
February	3	2	3	10	11
March	2	2	2	12	10
April	2	2	2	15	10
May	3	3	4	17	10
June	3	3	3	19	10
July	5	4	5	21	10
August	5	4	5	21	10
September	5	5	5	20	9
October	6	6	6	19	10
November	6	6	6	15	10
December	5	4	5	12	12

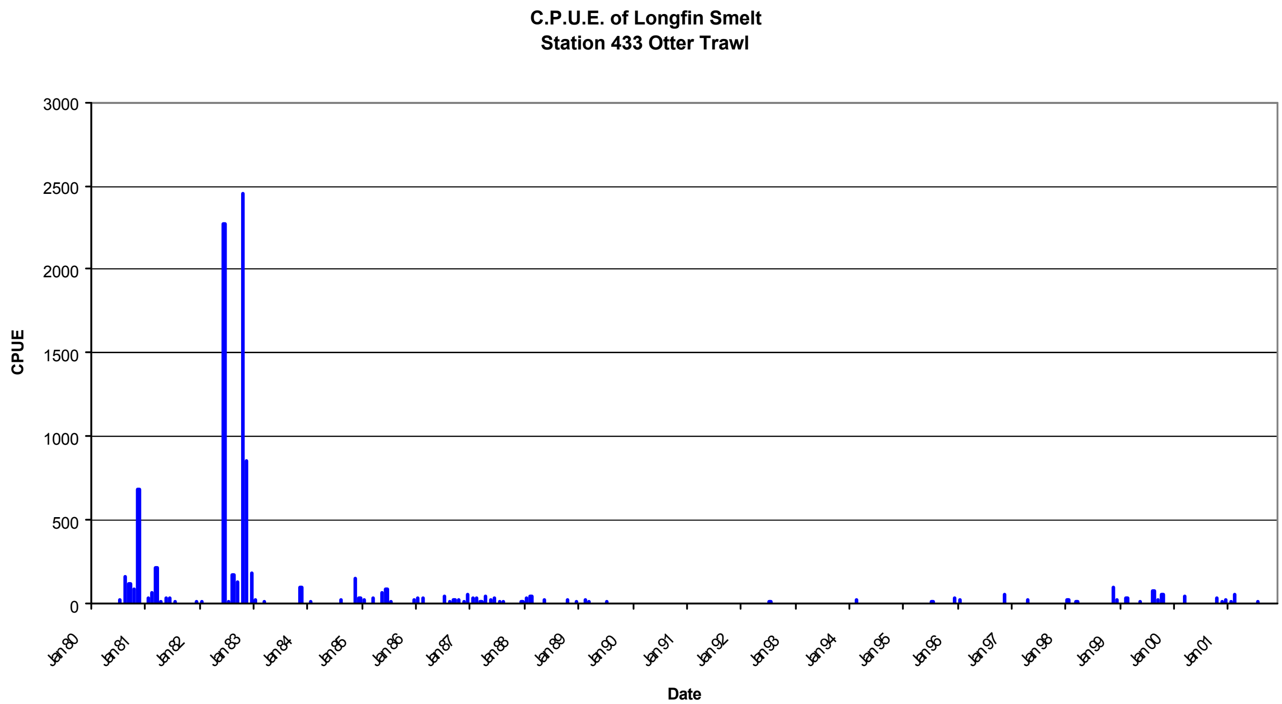
Species Compositions - Fish

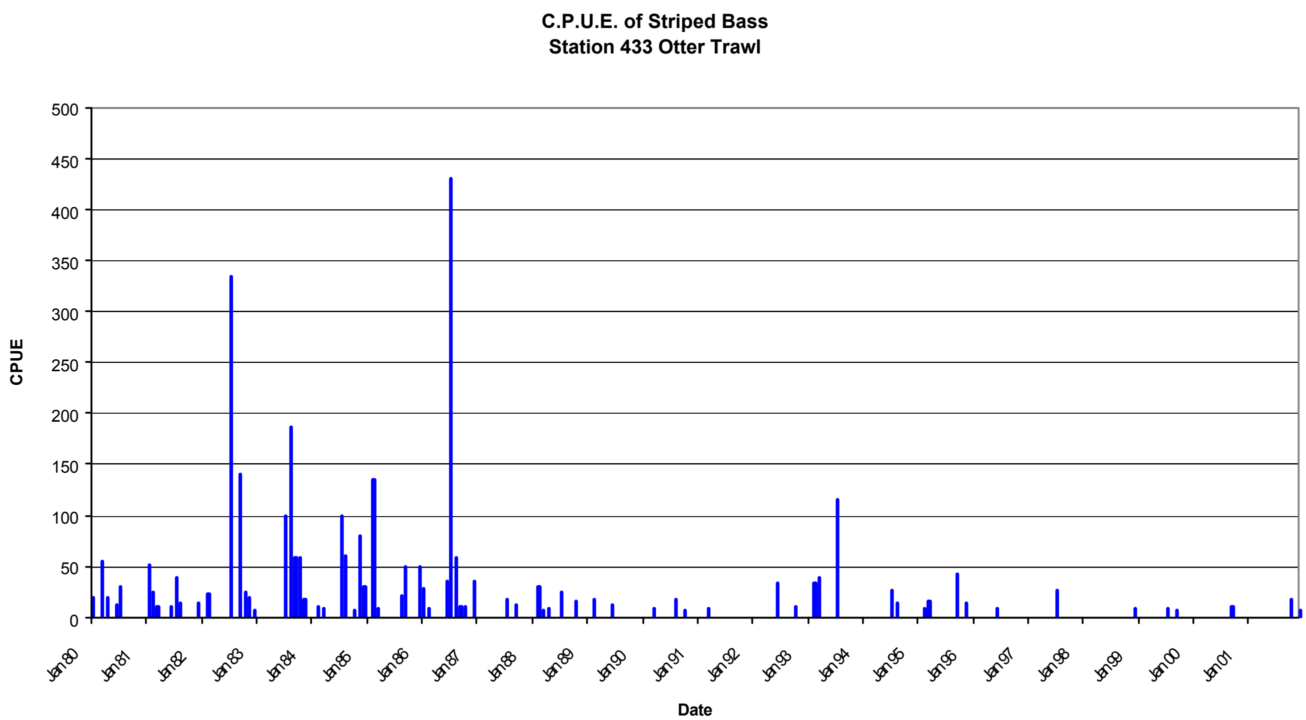
Station 433 Otter Trawl

Common Name	Percentage
longfin smelt	49.24%
striped bass	15.84%
yellowfin goby	15.46%
Pacific staghorn sculpin	5.03%
starry flounder	3.29%
white catfish	1.77%
bay goby	1.52%
bearded goby	1.39%
white sturgeon	1.27%
river lamprey	0.76%
delta smelt	0.63%
English sole	0.63%
channel catfish	0.55%
chameleon goby	0.51%
Pacific lamprey	0.42%
plainfin midshipman	0.38%
shimofuri goby	0.38%
threespine stickleback	0.30%
Pacific herring	0.13%
prickly sculpin	0.08%
speckled sanddab	0.08%
splittail	0.08%
American shad	0.04%
California tonguefish	0.04%
cheekspot goby	0.04%
threadfin shad	0.04%
western mosquitofish	0.04%
white croaker	0.04%

Station 428 Otter Trawl

Common Name	Percentage
longfin smelt	48.79%
striped bass	16.52%
Pacific staghorn sculpin	11.59%
yellowfin goby	8.31%
bay goby	3.79%
plainfin midshipman	1.78%
bearded goby	1.29%
starry flounder	1.26%
delta smelt	0.93%
river lamprey	0.85%
white croaker	0.85%
chameleon goby	0.65%
Pacific lamprey	0.59%
shimofuri goby	0.57%
white sturgeon	0.36%
English sole	0.31%
speckled sanddab	0.28%
threespine stickleback	0.23%
prickly sculpin	0.18%
white catfish	0.15%
Pacific herring	0.10%
splittail	0.10%
American shad	0.08%
California halibut	0.05%
cheekspot goby	0.05%
chinook salmon	0.05%
green sturgeon	0.05%
Pacific tomcod	0.05%
shiner perch	0.05%
brown smoothhound	0.03%
California tonguefish	0.03%
sand sole	0.03%
topsmelt	0.03%


C.P.U.E. of Longfin Smelt
Station 433 Otter Trawl
CPUE
3000
2500
2000
1500
1000
500
0
Jan 80
Jan 81
Jan 82
Jan 83
Jan 84
Jan 85
Jan 86
Jan 87
Jan 88
Jan 89
Jan 90
Jan 91
Jan 92
Jan 93
Jan 94
Jan 95
Jan 96
Jan 97
Jan 98
Jan 99
Jan 00
Jan 01
Date


C.P.U.E. of Striped Bass
Station 433 Otter Trawl
CPUE
500
450
400
350
300
250
200
150
100
50
0
Jan 80
Jan 81
Jan 82
Jan 83
Jan 84
Jan 85
Jan 86
Jan 87
Jan 88
Jan 89
Jan 90
Jan 91
Jan 92
Jan 93
Jan 94
Jan 95
Jan 96
Jan 97
Jan 98
Jan 99
Jan 00
Jan 01
Date

Station 428 Otter Trawl

Common Name	Percentage
longfin smelt	48.79%
striped bass	16.52%
Pacific staghorn sculpin	11.59%
yellowfin goby	8.31%
bay goby	3.79%
plainfin midshipman	1.78%
bearded goby	1.29%
starry flounder	1.26%
delta smelt	0.93%
river lamprey	0.85%
white croaker	0.85%
chameleon goby	0.65%
Pacific lamprey	0.59%
shimofuri goby	0.57%
white sturgeon	0.36%
English sole	0.31%
speckled sanddab	0.28%
threespine stickleback	0.23%
prickly sculpin	0.18%
white catfish	0.15%
Pacific herring	0.10%
splittail	0.10%
American shad	0.08%
California halibut	0.05%
cheekspot goby	0.05%
chinook salmon	0.05%
green sturgeon	0.05%
Pacific tomcod	0.05%
shiner perch	0.05%
brown smoothhound	0.03%
California tonguefish	0.03%
sand sole	0.03%
topsmelt	0.03%

Station 534 Otter Trawl

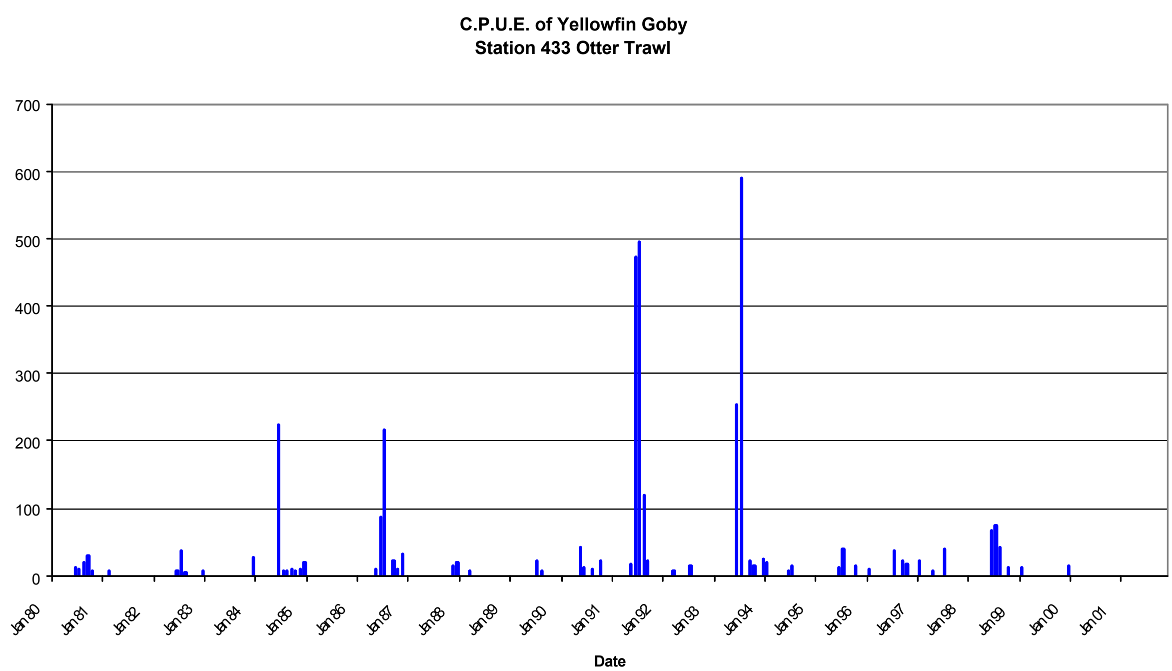
Common Name	Percentage
striped bass	74.04%
yellowfin goby	9.91%
starry flounder	6.10%
longfin smelt	3.63%
Pacific staghorn sculpin	1.43%
splittail	1.43%
delta smelt	0.84%
American shad	0.68%
white sturgeon	0.62%
English sole	0.34%
threadfin shad	0.18%
common carp	0.15%
tule perch	0.09%
chameleon goby	0.06%
chinook salmon	0.05%
green sturgeon	0.05%
shimofuri goby	0.05%
threespine stickleback	0.04%
white catfish	0.04%
bearded goby	0.03%
Pacific lamprey	0.03%
plainfin midshipman	0.03%
prickly sculpin	0.03%
Sacramento sucker	0.03%
bay goby	0.02%
channel catfish	0.02%
speckled sanddab	0.02%
river lamprey	0.01%
white croaker	0.01%

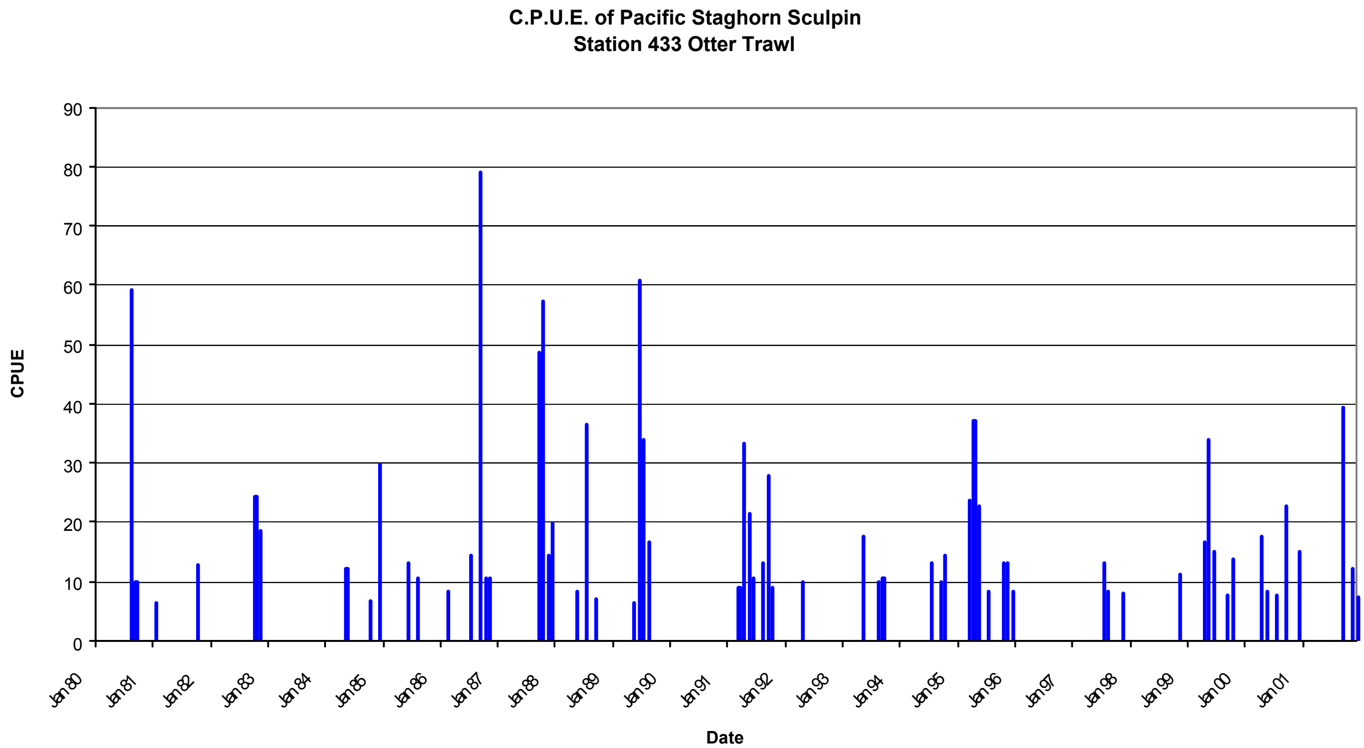
Station 433 Midwater Trawl

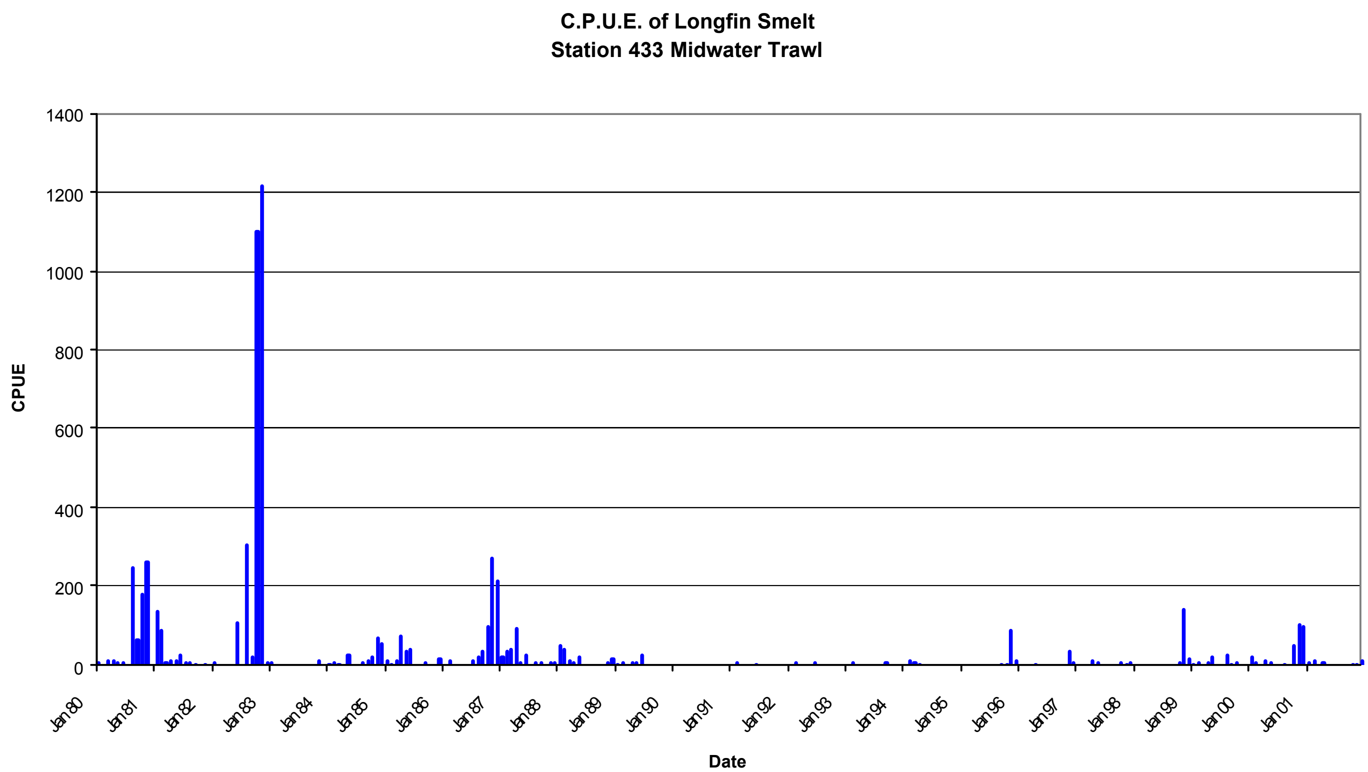
Common Name	Percentage
longfin smelt	53.40%
striped bass	19.28%
northern anchovy	17.24%
American shad	2.54%
yellowfin goby	2.13%
chinook salmon	1.60%
delta smelt	1.11%
Pacific herring	0.77%
starry flounder	0.58%
splittail	0.27%
white sturgeon	0.24%
white croaker	0.16%
Pacific staghorn sculpin	0.14%
threadfin shad	0.14%
shimofuri goby	0.08%
white catfish	0.08%
chameleon goby	0.06%
common carp	0.03%
Sacramento pikeminnow	0.03%
shiner perch	0.03%
bay goby	0.02%
channel catfish	0.02%
green sturgeon	0.02%
plainfin midshipman	0.02%
steelhead trout	0.02%
threespine stickleback	0.02%

Stations 428 Midwater Trawl

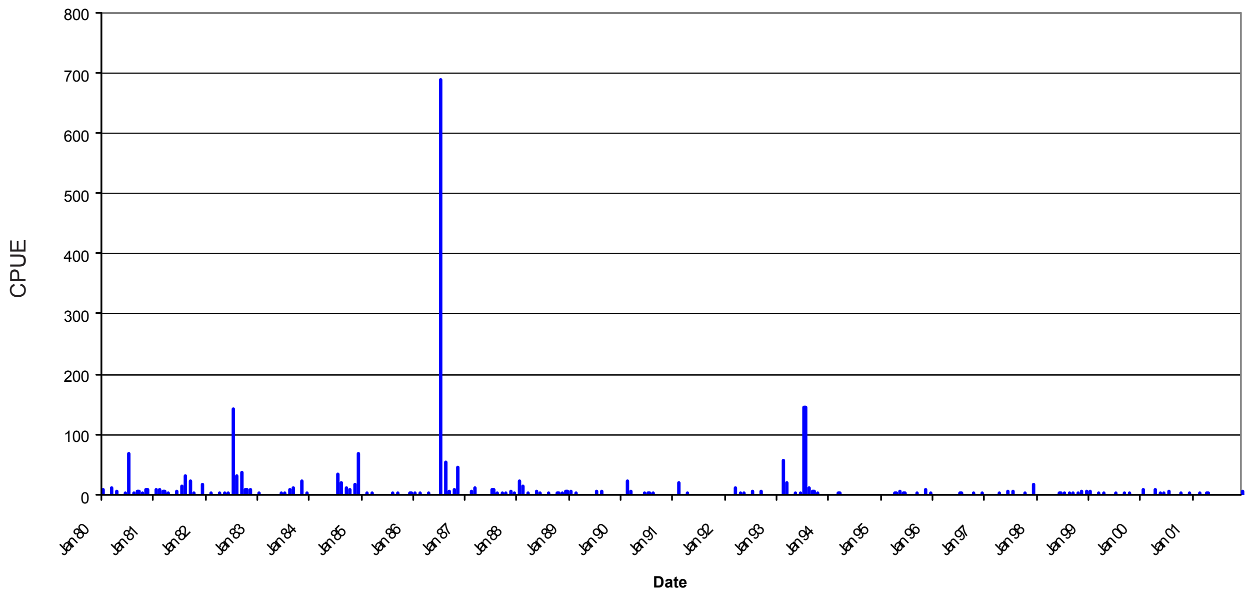
Common Name	Percentage
northern anchovy	50.01%
longfin smelt	33.67%
striped bass	9.47%
Pacific herring	1.87%
yellowfin goby	1.22%
American shad	0.80%
chinook salmon	0.72%
white croaker	0.50%
plainfin midshipman	0.48%
delta smelt	0.42%
Pacific staghorn sculpin	0.20%
starry flounder	0.19%
splittail	0.15%
white sturgeon	0.10%
shimofuri goby	0.04%
threadfin shad	0.04%
jacksmelt	0.02%
threespine stickleback	0.02%
chameleon goby	0.01%
bay goby	0.01%
common carp	0.01%
Pacific lamprey	0.01%
Pacific pompano	0.01%
river lamprey	0.01%
shiner perch	0.01%
speckled sanddab	0.01%
steelhead trout	0.01%
surf smelt	0.01%



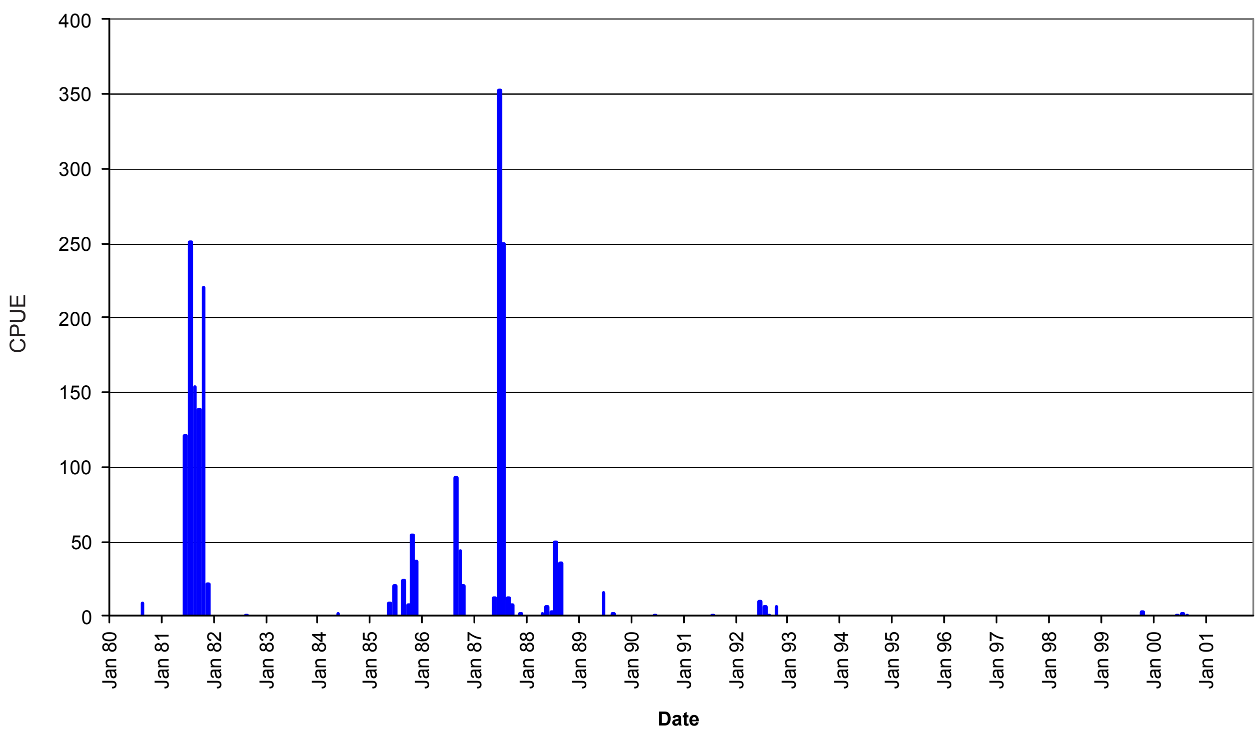

C.P.U.E. of Pacific Staghorn Sculpin
Station 433 Otter Trawl
CPUE
90
80
70
60
50
40
30
20
10
0
Jan 80
Jan 81
Jan 82
Jan 83
Jan 84
Jan 85
Jan 86
Jan 87
Jan 88
Jan 89
Jan 90
Jan 91
Jan 92
Jan 93
Jan 94
Jan 95
Jan 96
Jan 97
Jan 98
Jan 99
Jan 00
Jan 01
Date


C.P.U.E. of Longfin Smelt
Station 433 Midwater Trawl
CPUE
1400
1200
1000
800
600
400
200
0
Jan 80
Jan 81
Jan 82
Jan 83
Jan 84
Jan 85
Jan 86
Jan 87
Jan 88
Jan 89
Jan 90
Jan 91
Jan 92
Jan 93
Jan 94
Jan 95
Jan 96
Jan 97
Jan 98
Jan 99
Jan 00
Jan 01
Date

C.P.U.E. of Striped Bass
Station 433 Midwater Trawl



C.P.U.E. of Northern Anchovy
Station 433 Midwater Trawl



Station 534 Midwater Trawl

Common Name	Percentage 534
striped bass	30.08%
American shad	17.23%
longfin smelt	13.59%
northern anchovy	13.52%
delta smelt	8.34%
threadfin shad	8.03%
splittail	2.71%
yellowfin goby	2.21%
white sturgeon	1.12%
chinook salmon	0.88%
Pacific herring	0.76%
starry flounder	0.74%
common carp	0.21%
threespine stickleback	0.12%
jacksmelt	0.10%
Pacific staghorn sculpin	0.07%
topsmelt	0.07%
white catfish	0.05%
white croaker	0.05%
prickly sculpin	0.02%
Sacramento sucker	0.02%
steelhead trout	0.02%
surf smelt	0.02%
tule perch	0.02%

Species Composition - Crab

Station 433 Otter Trawl

Common Name	Percentage 433
Dungeness crab	66.67%
Chinese mitten crab	33.33%

Station 428 Otter Trawl

Common Name	Percentage 428
Dungeness crab	79.67%
Chinese mitten crab	19.92%
arched swimming crab	0.41%

Station 534 Otter Trawl

Common Name	Percentage 534
Chinese mitten crab	94.12%
Dungeness crab	5.88%

Species Composition – Shrimp

Station 433 Otter Trawl

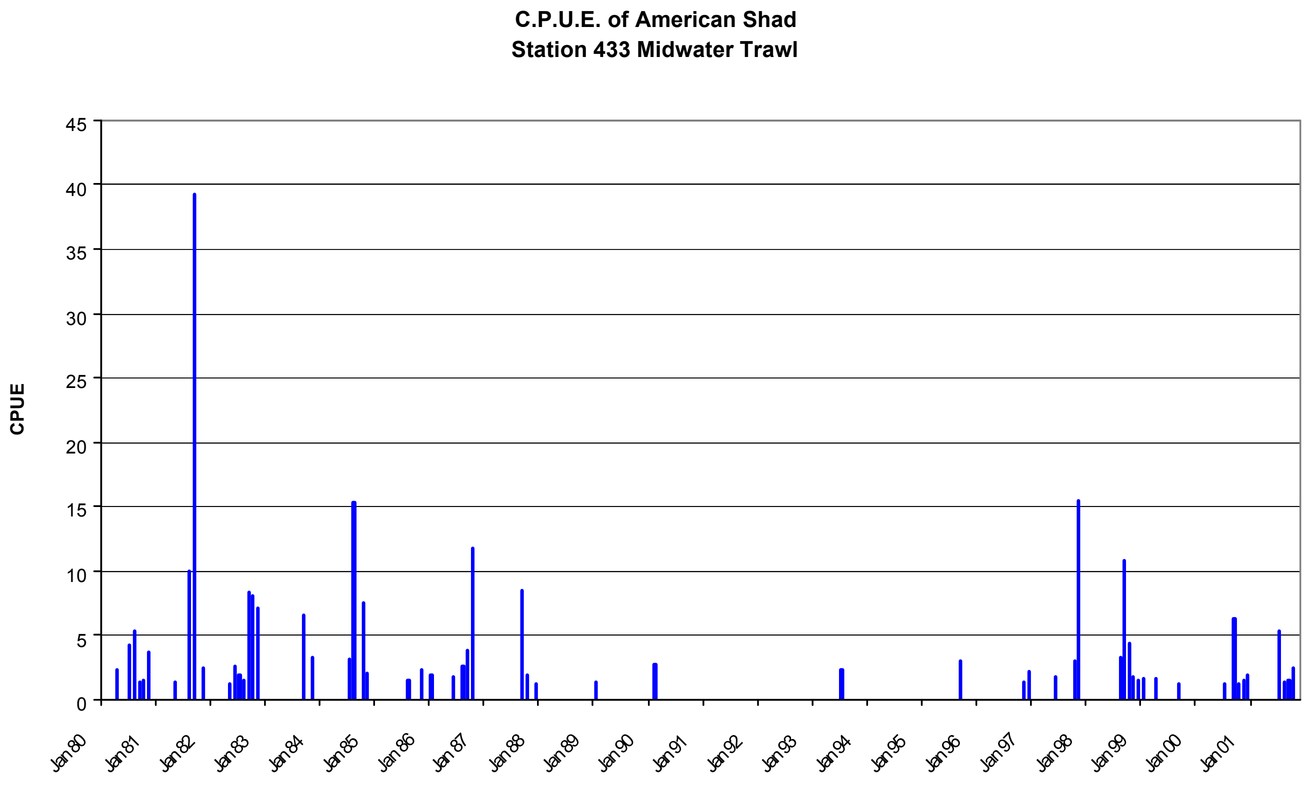
Common Name	Percentage 433
California bay shrimp	93.78%
oriental shrimp	6.11%
blacktail bay shrimp	0.12%

Station 428 Otter Trawl

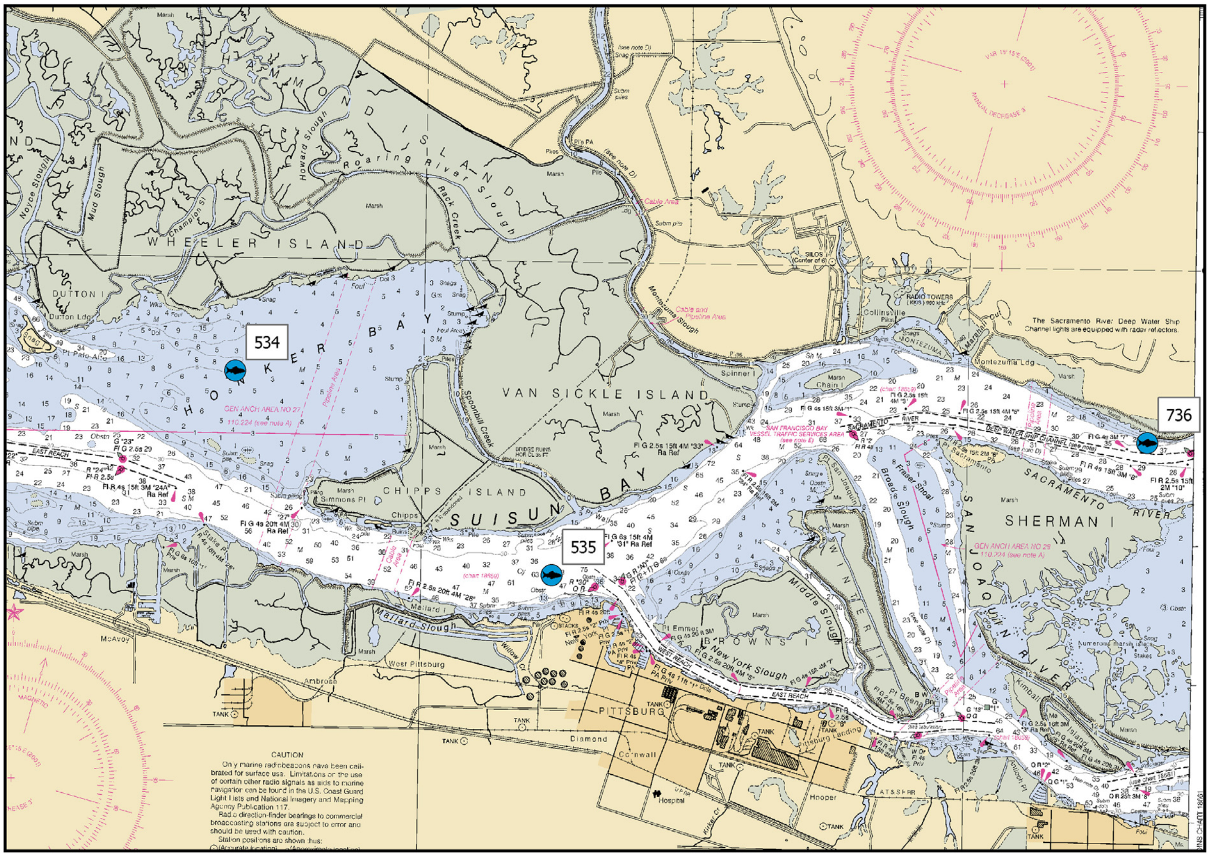
Common Name	Percentage 428
California bay shrimp	92.16%
oriental shrimp	4.17%
blacktail bay shrimp	3.67%
Stimpson coastal shrimp	0.00%
blackspotted bay shrimp	0.00%

Station 534 Otter Trawl

Common Name	Percentage 534
California bay shrimp	99.18%
oriental shrimp	0.81%
blacktail bay shrimp	0.01%


C.P.U.E. of American Shad
Station 433 Midwater Trawl
CPUE
45
40
35
30
25
20
15
10
5
0
Jan 80
Jan 81
Jan 82
Jan 83
Jan 84
Jan 85
Jan 86
Jan 87
Jan 88
Jan 89
Jan 90
Jan 91
Jan 92
Jan 93
Jan 94
Jan 95
Jan 96
Jan 97
Jan 98
Jan 99
Jan 00
Jan 01

Suisun Bay



Suisun Bay
CDFG Sampling Stations

Physical Characteristics

Salinity, Temperature and Depth of Sampling Location Station 535

	Average Salinity (ppt)	Surface Salinity (ppt)	Bottom Salinity (ppt)	Average Temperature (C°)	Average Depth
January	4	3	4	8	35
February	2	2	2	9	35
March	2	1	2	12	34
April	1	1	1	15	36
May	2	2	2	17	36
June	2	2	2	20	35
July	3	2	3	21	35
August	2	2	2	21	36
September	4	3	4	21	36
October	5	4	5	19	35
November	4	4	5	16	35
December	3	3	3	12	38

Salinity, Temperature and Depth of Sampling Location Station 534

	Average Salinity (ppt)	Surface Salinity (ppt)	Bottom Salinity (ppt)	Average Temperature (C°)	Average Depth
January	5	4	5	8	10
February	3	2	3	10	11
March	2	2	2	12	10
April	2	2	2	15	10
May	3	3	4	17	10
June	3	3	3	19	10
July	5	4	5	21	10
August	5	4	5	21	10
September	5	5	5	20	9
October	6	6	6	19	10
November	6	6	6	15	10
December	5	4	5	12	12

Salinity, Temperature and Depth of Sampling Location Station 736

	Average Salinity (ppt)	Surface Salinity (ppt)	Bottom Salinity (ppt)	Average Temperature (C°)	Average Depth
January	1	1	2	8	37
February	1	1	1	9	38
March	1	1	1	12	37
April	0	0	0	15	37
May	1	1	1	17	35
June	1	1	1	19	36
July	1	1	1	21	37
August	1	1	1	21	36
September	2	2	2	21	37
October	2	2	2	19	36
November	2	2	3	16	36
December	2	1	2	11	36

Species Composition - Fish

Station 535 Otter Trawl

Common Name	Percentage
striped bass	27.54%
yellowfin goby	23.73%
longfin smelt	22.17%
white catfish	10.78%
Pacific staghorn sculpin	4.06%
channel catfish	2.30%
delta smelt	1.76%
white sturgeon	1.52%
starry flounder	1.19%
bearded goby	0.70%
splittail	0.70%
Pacific lamprey	0.49%
river lamprey	0.45%
threespine stickleback	0.45%
American shad	0.25%
bay goby	0.25%
Pacific herring	0.25%
shimofuri goby	0.25%
prickly sculpin	0.16%
chinook salmon	0.12%
English sole	0.12%
plainfin midshipman	0.12%
bigscale logperch	0.08%
California halibut	0.08%
chameleon goby	0.08%
green sturgeon	0.08%
threadfin shad	0.08%
white croaker	0.08%
common carp	0.04%
inland silverside	0.04%
speckled sanddab	0.04%
tule perch	0.04%

Station 534 Otter Trawl

Common Name	Percentage
striped bass	74.04%
yellowfin goby	9.91%
starry flounder	6.10%
longfin smelt	3.63%
Pacific staghorn sculpin	1.43%
splittail	1.43%
delta smelt	0.84%
American shad	0.68%
white sturgeon	0.62%
English sole	0.34%
threadfin shad	0.18%
common carp	0.15%
tule perch	0.09%
chameleon goby	0.06%
chinook salmon	0.05%
green sturgeon	0.05%
shimofuri goby	0.05%
threespine stickleback	0.04%
white catfish	0.04%
bearded goby	0.03%
Pacific lamprey	0.03%
plainfin midshipman	0.03%
prickly sculpin	0.03%
Sacramento sucker	0.03%
bay goby	0.02%
channel catfish	0.02%
speckled sanddab	0.02%
river lamprey	0.01%
white croaker	0.01%

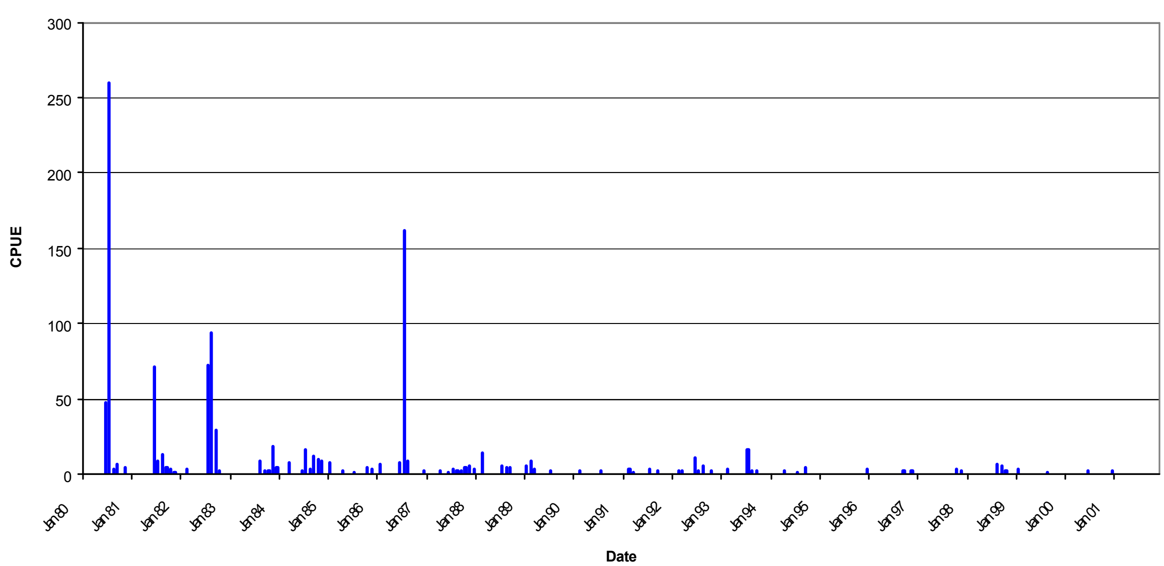
Station 736 Otter Trawl

Common Name	Percentage
striped bass	37.23%
white catfish	15.38%
yellowfin goby	13.41%
channel catfish	9.44%
longfin smelt	8.25%
white sturgeon	4.74%
delta smelt	2.43%
bearded goby	1.97%
starry flounder	1.50%
Pacific staghorn sculpin	1.31%
river lamprey	0.85%
chameleon goby	0.73%
shimofuri goby	0.69%
Pacific lamprey	0.58%
prickly sculpin	0.35%
chinook salmon	0.23%
plainfin midshipman	0.15%
green sturgeon	0.12%
Pacific herring	0.12%
splittail	0.12%
bay goby	0.08%
tule perch	0.08%
bigscale logperch	0.04%
common carp	0.04%
speckled sanddab	0.04%
threadfin shad	0.04%
threespine stickleback	0.04%
wakasagi	0.04%
western mosquitofish	0.04%

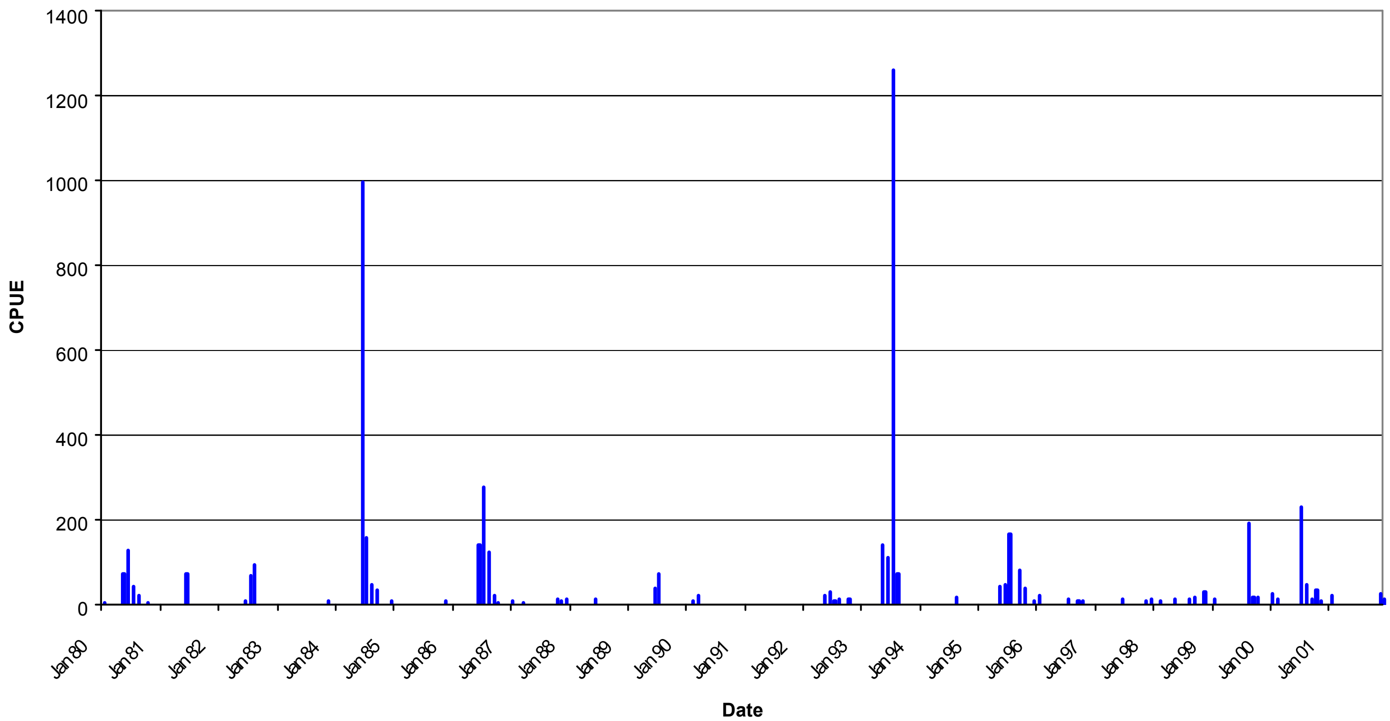
Station 535 Midwater Trawl

Common Name	Percentage 535
striped bass	47.40%
longfin smelt	30.60%
northern anchovy	5.72%
yellowfin goby	4.50%
American shad	3.39%
chinook salmon	3.10%
delta smelt	2.65%
Pacific herring	0.63%
threadfin shad	0.50%
starry flounder	0.34%
white sturgeon	0.30%
splittail	0.29%
chameleon goby	0.13%
Pacific staghorn sculpin	0.13%
plainfin midshipman	0.07%
white catfish	0.05%
channel catfish	0.04%
steelhead trout	0.04%
white croaker	0.04%
goldfish	0.02%
Pacific tomcod	0.02%
river lamprey	0.02%
shiner perch	0.02%
tule perch	0.02%

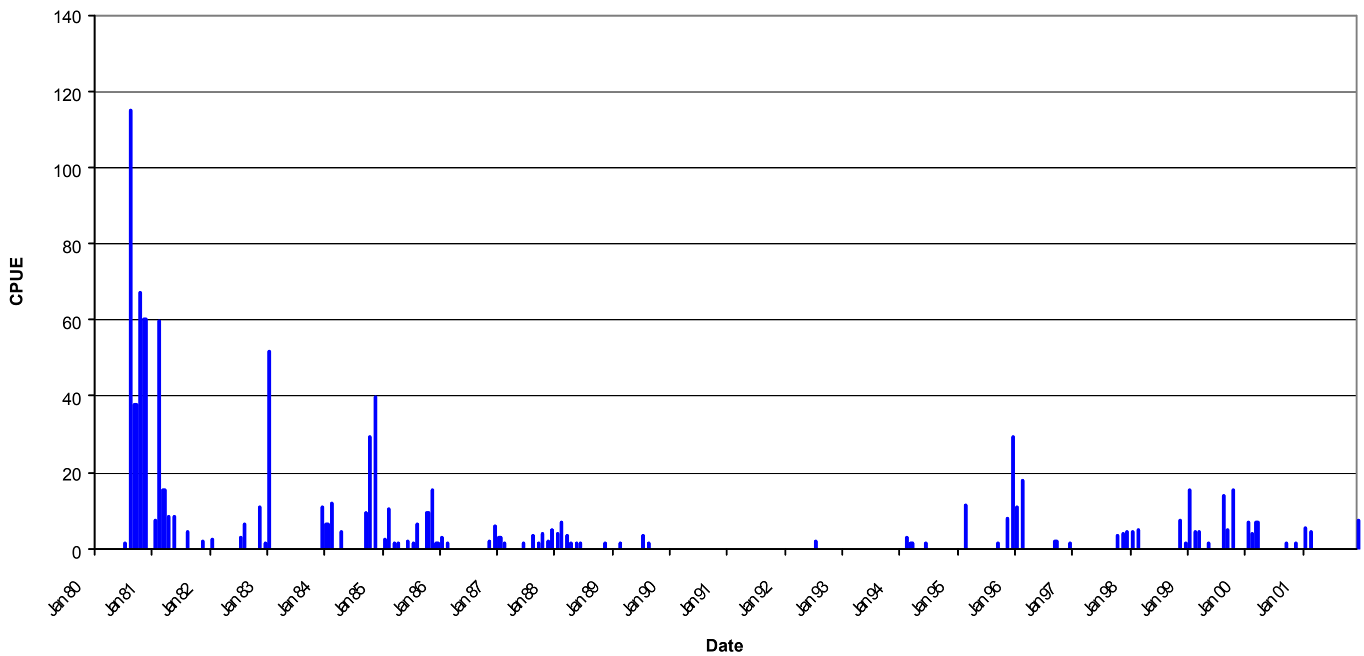
C.P.U.E. of Striped Bass
Station 535 Otter Trawl

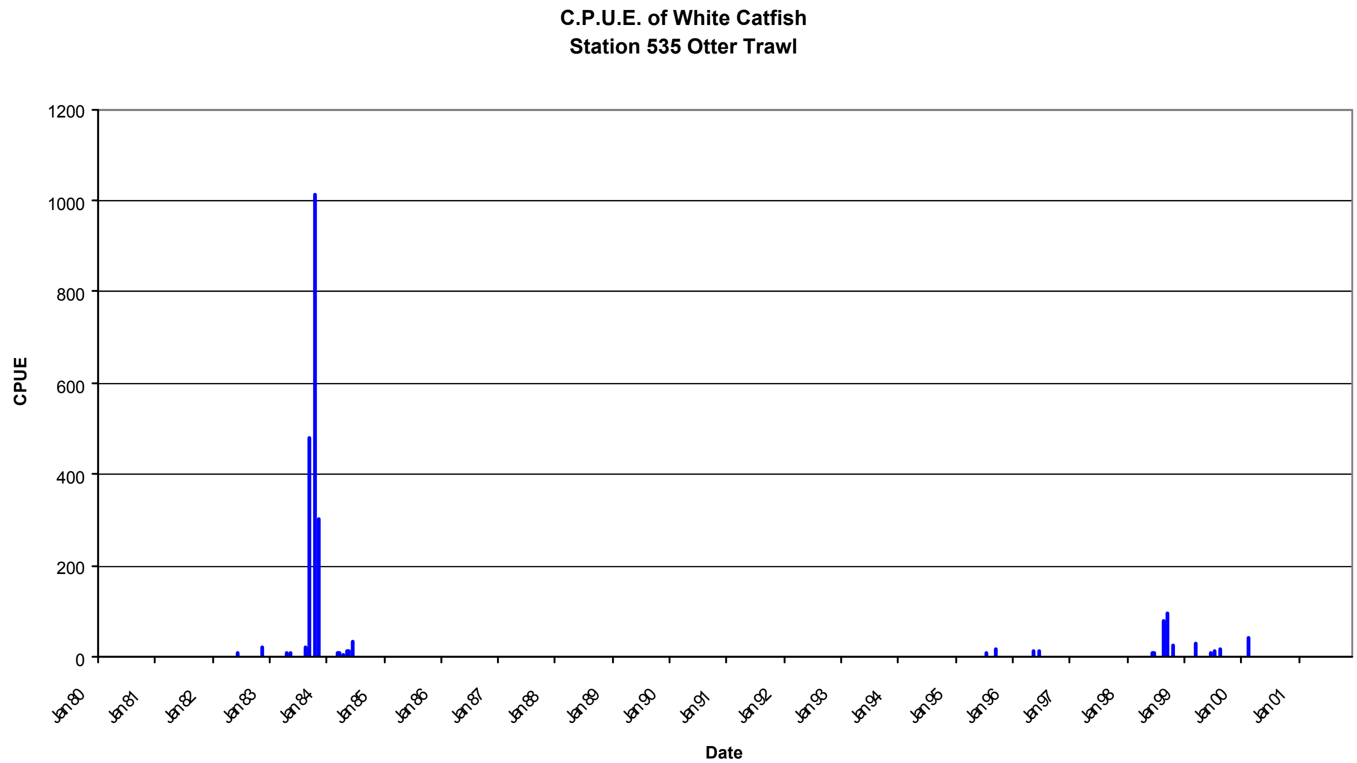


C.P.U.E. of Yellowfin Goby
Station 535 Otter Trawl



C.P.U.E. of Longfin Smelt
Station 535 Otter Trawl




C.P.U.E. of White Catfish
Station 535 Otter Trawl
CPUE
1200
1000
800
600
400
200
0
Jan 80
Jan 81
Jan 82
Jan 83
Jan 84
Jan 85
Jan 86
Jan 87
Jan 88
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Jan 92
Jan 93
Jan 94
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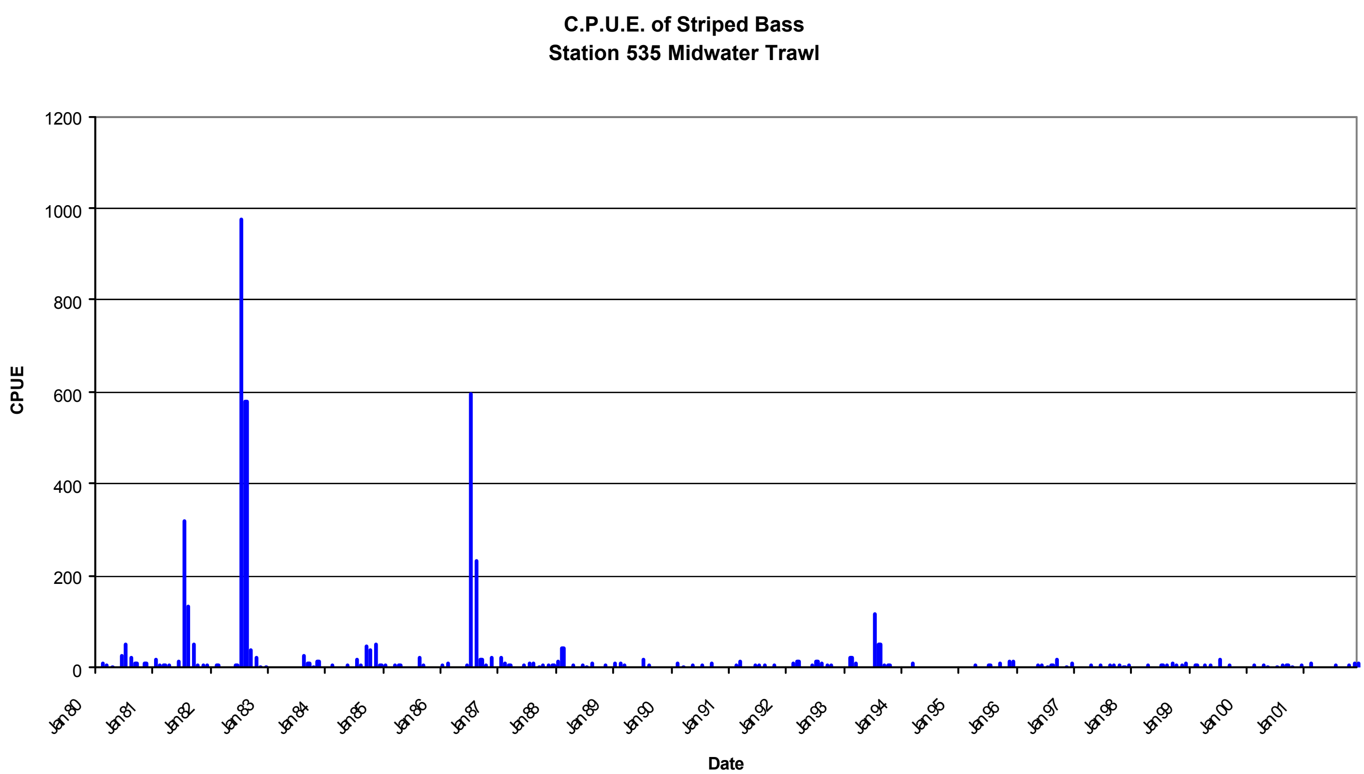
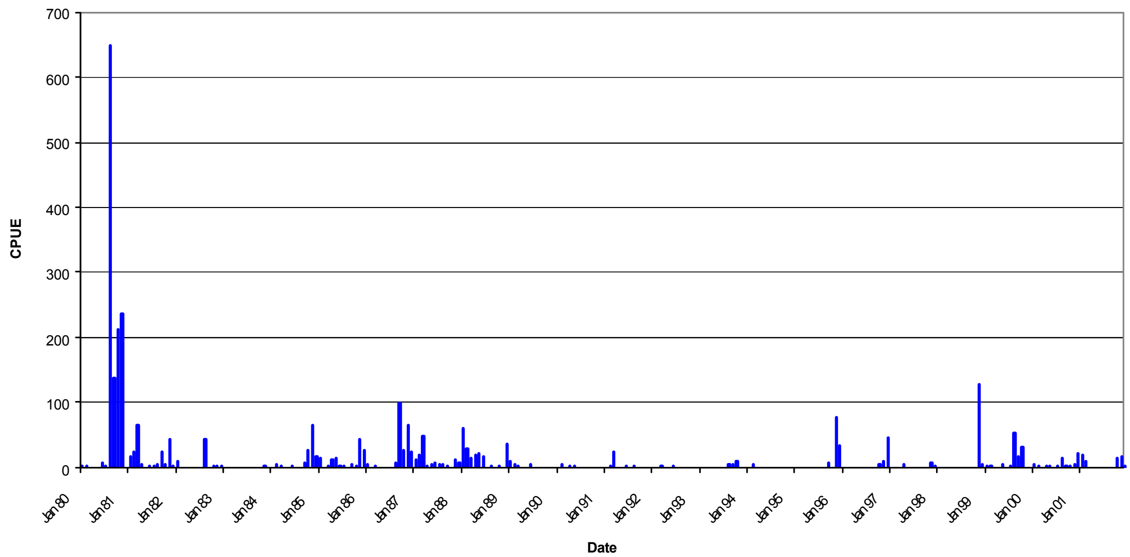
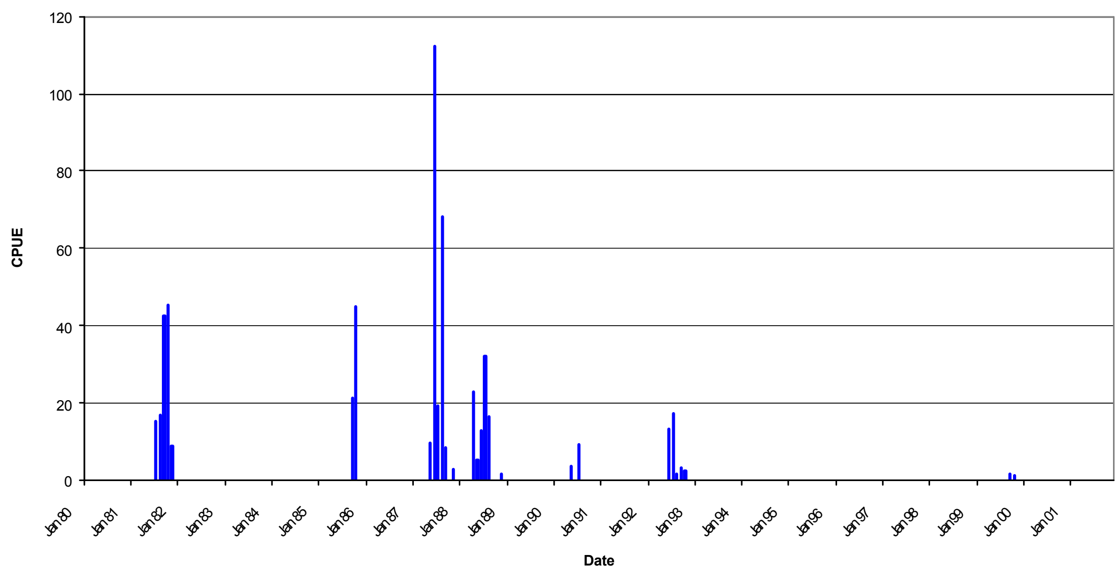
Jan 96
Jan 97
Jan 98
Jan 99
Jan 00
Jan 01
Date


C.P.U.E. of Striped Bass
Station 535 Midwater Trawl
CPUE
1200
1000
800
600
400
200
0
Jan 80
Jan 81
Jan 82
Jan 83
Jan 84
Jan 85
Jan 86
Jan 87
Jan 88
Jan 89
Jan 90
Jan 91
Jan 92
Jan 93
Jan 94
Jan 95
Jan 96
Jan 97
Jan 98
Jan 99
Jan 00
Jan 01
Date

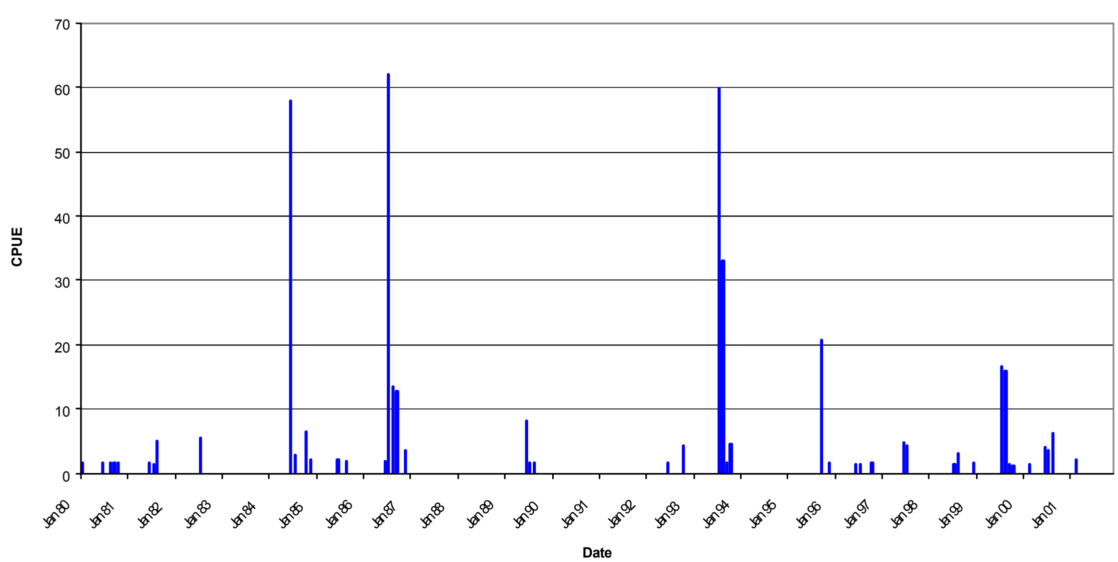
C.P.U.E. of Longfin Smelt
Station 535 Midwater Trawl



C.P.U.E. of Northern Anchovy
Station 535 Midwater Trawl



Station 535 Midwater Trawl



APPENDIX H

Summary of Biological Response of Fish and Macroinvertebrates to Suspended Sediment Exposure

Primary Reference	Secondary Reference	Species/Lifestage	Life Stage	Species: Fish/ Invertebrate	Reported Effects Conc. (mg/l TSS)	Test Duration (hours)	Response	Response Type	Type of Sediment
Wilber and Clarke 2001	Huntington and Miller 1989	Northern quahog larvae	L	I	56	12	No effect level	No Effect	Not Reported
Wilber and Clarke 2001	Huntington and Miller 1989	Northern quahog larvae	L	I	56	24	No effect level	No Effect	Not Reported
Wilber and Clarke 2001	Huntington and Miller 1989	Northern quahog larvae	L	I	56	48	No effect level	No Effect	Not Reported
Clarke and Wilber 2000	Kiorboe *et al.* 1981	Striped bass eggs	E	F	100	24	Delayed hatching	Sublethal	Not Reported
Clarke and Wilber 2000	Kiorboe *et al.* 1981	White perch eggs	E	F	100	24	Delayed hatching	Sublethal	Not Reported
Wilber and Clarke 2001	Schubel and Wang 1973	White perch eggs	E	F	100	24	Hatching delayed	Sublethal	Not Reported
Wilber and Clarke 2001	Robinson *et al.* 1984	Surf clam		I	100	72	No effect level	No Effect	Artificial
Wilber and Clarke 2001	Turner and Miller 1991	Northern quahog		I	100	48	Reduced growth	Sublethal	Natural
Wilber and Clarke 2001	Huntington and Miller 1989	Northern quahog larvae	L	I	110	24	No effect level	No Effect	Not Reported
Wilber and Clarke 2001	Huntington and Miller 1989	Northern quahog larvae	L	I	110	24	No effect level	No Effect	Not Reported
Wilber and Clarke 2001	Huntington and Miller 1989	Northern quahog larvae	L	I	110	48	No effect level	No Effect	Not Reported
Wilber and Clarke 2001	Turner and Miller 1991	Northern quahog		I	120	48	Reduced growth	Sublethal	Natural
Wilber and Clarke 2001	Morgan *et al.* 1973	White perch larvae	L	F	155	48	50% mortality	Lethal	Not Reported
Wilber and Clarke 2001	Turner and Miller 1991	Northern quahog		I	193	48	Reduced growth	Sublethal	Natural
Wilber and Clarke 2001	Cardwell *et al.* 1976	Pacific oyster larvae	L	I	200	48	No effect level	No Effect	Natural
Wilber and Clarke 2001	Breitburg 1988	Striped bass larvae	L	F	200	12	Reduced feeding rate	Sublethal	Artificial
Wilber and Clarke 2001	Huntington and Miller 1989	Northern quahog larvae	L	I	220	12	No effect level	No Effect	Not Reported
Wilber and Clarke 2001	Huntington and Miller 1989	Northern quahog larvae	L	I	220	24	No effect level	No Effect	Not Reported
Wilber and Clarke 2001	Huntington and Miller 1989	Northern quahog larvae	L	I	220	48	No effect level	No Effect	Not Reported
Wilber and Clarke 2001	Morgan *et al.* 1973	White perch larvae	L	F	373	24	50% mortality	Lethal	Not Reported
Wilber and Clarke 2001	Morgan *et al.* 1973	Striped bass larvae	L	F	485	24	50% mortality	Lethal	Not Reported
Clarke and Wilber 2000	Sherk *et al.* 1974 and 1975	Bluefish subadult	J	F	500	24	10% mortality	Lethal	Artificial
Wilber and Clarke 2001	Auld and Schubel 1978	Striped bass larvae	L	F	500	72	Increased mortality	Lethal	Natural
Wilber and Clarke 2001	Cardwell *et al.* 1976	Pacific oyster larvae	L	I	500	48	No effect level	No Effect	Natural
Wilber and Clarke 2001	Robinson *et al.* 1984	Surf clam		I	500	72	No effect level	No Effect	Artificial

Wilber and Clarke 2001	Kiorboe *et al.* 1981	Atlantic herring eggs	E	F	500	12	Normal egg development level	Sublethal	Natural
Wilber and Clarke 2001	Breitburg 1988	Striped bass larvae	L	F	500	12	Reduced feeding rate	Sublethal	Artificial
Clarke and Wilber 2000	Messieh *et al.* 1981	Atlantic herring larvae	L	F	540	48	Reduced growth	Sublethal	Not Reported
Wilber and Clarke 2001	Huntington and Miller 1989	Northern quahog larvae	L	I	560	12	No effect level	No Effect	Not Reported
Wilber and Clarke 2001	Huntington and Miller 1989	Northern quahog larvae	L	I	560	24	No effect level	No Effect	Not Reported
Wilber and Clarke 2001	Huntington and Miller 1989	Northern quahog larvae	L	I	560	48	No effect level	No Effect	Not Reported
Wilber and Clarke 2001	Sherk *et al.* 1974	Atlantic silverside		F	580	24	10% mortality	Lethal	Artificial
Lunz 1987	Stern and Stickle 1978	Atlantic silverside adult	A	F	580	24	Not reported	N/AV	Artificial
Wilber and Clarke 2001	Cardwell *et al.* 1976	Pacific oyster larvae	L	I	600	48	No effect level	No Effect	Natural
Wilber and Clarke 2001	Sherk *et al.* 1974	White perch		F	670	48	10% mortality	Lethal	Artificial
Wilber and Clarke 2001	Sherk *et al.* 1974	White perch subadult	J	F	750	24	100% mortality	Lethal	Artificial
Wilber and Clarke 2001	Sherk *et al.* 1974	Atlantic menhaden subadult	J	F	800	24	100% mortality	Lethal	Artificial
Wilber and Clarke 2001	Sherk *et al.* 1974	Bluefish subadult	J	F	800	24	100% mortality	Lethal	Artificial
Wilber and Clarke 2001	Cardwell *et al.* 1976	Pacific oyster larvae	L	I	800	48	50% mortality	Lethal	Natural
Wilber and Clarke 2001	Morgan *et al.* 1983	Striped bass eggs	E	F	800	24	Development slowed	Sublethal	Natural
Clarke and Wilber 2000	Sherk *et al.* 1974 and 1975	Atlantic croaker adult	A	F	1000	24	10% mortality	Lethal	Artificial
Clarke and Wilber 2000	Sherk *et al.* 1974 and 1975	Bay anchovy adult	A	F	1000	24	10% mortality	Lethal	Artificial
Clarke and Wilber 2000	Sherk *et al.* 1974 and 1975	Menhaden subadult	J	F	1000	24	10% mortality	Lethal	Artificial
Clarke and Wilber 2000	Sherk *et al.* 1974 and 1975	Striped bass adult	A	F	1000	24	10% mortality	Lethal	Artificial
Clarke and Wilber 2000	Sherk *et al.* 1974 and 1975	Weakfish		F	1000	24	10% mortality	Lethal	Artificial
Wilber and Clarke 2001	Cardwell *et al.* 1976	Pacific oyster larvae	L	I	1000	48	50% mortality	Lethal	Natural
Wilber and Clarke 2001	Boehlert 1984	Pacific herring larvae	L	F	1000	24	Damage to epidermis	Sublethal	Natural
Wilber and Clarke 2001	Auld and Schubel 1978	Striped bass larvae	L	F	1000	72	Increased mortality	Lethal	Natural
Wilber and Clarke 2001	Cardwell *et al.* 1976	Pacific oyster larvae	L	I	1000	48	No effect level	No Effect	Natural
Wilber and Clarke 2001	Robinson *et al.* 1984	Surf clam		I	1000	72	No effect level	No Effect	Artificial
Wilber and Clarke 2001	Loosanoff 1962	Eastern oyster adult	A	I	1000	48	Reduced pumping	Sublethal	Natural
Wilber and Clarke 2001	Sherk *et al.* 1974	Spot		F	1140	48	10% mortality	Lethal	Artificial

Wilber and Clarke 2001	Cardwell *et al.* 1976	Pacific oyster larvae	L	I	1200	48	Abnormal shell development	Sublethal	Natural
Wilber and Clarke 2001	Cardwell *et al.* 1976	Pacific oyster larvae	L	I	1500	48	50% mortality	Lethal	Natural
Lunz 1987	Morton 1977	Striped bass larvae	L	F	1557	72	Not reported	N/AV	Natural
Lunz 1987	Morton 1977	White perch larvae	L	F	1626	72	Not reported	N/AV	Natural
Wilber and Clarke 2001	Cardwell *et al.* 1976	Pacific oyster larvae	L	I	1800	48	Abnormal shell development	Sublethal	Natural
Wilber and Clarke 2001	Cardwell *et al.* 1976	Pacific oyster larvae	L	I	1800	48	No effect level	No Effect	Natural
Wilber and Clarke 2001	Sherk *et al.* 1974	Spot		F	1890	48	50% mortality	Lethal	Artificial
Wilber and Clarke 2001	Boehlert and Morgan 1985	Pacific herring larvae	L	F	2000	12	Reduced feeding rate	Sublethal	Not Reported
Wilber and Clarke 2001	Loosanoff 1962	Eastern oyster adult	A	I	2000	48	Reduced pumping	Sublethal	Natural
Wilber and Clarke 2001	Huntington and Miller 1989	Northern quahog larvae	L	I	2200	12	No effect level	No Effect	Not Reported
Wilber and Clarke 2001	Huntington and Miller 1989	Northern quahog larvae	L	I	2200	24	No effect level	No Effect	Not Reported
Wilber and Clarke 2001	Huntington and Miller 1989	Northern quahog larvae	L	I	2200	48	Reduced growth	Sublethal	Not Reported
Lunz 1987	Stern and Stickle 1978	Bay anchovy adult	A	F	2300	24	Not reported	N/AV	Artificial
Wilber and Clarke 2001	Sherk *et al.* 1975	Bay anchovy		F	2310	24	10% mortality	Lethal	Artificial
Wilber and Clarke 2001	Sherk *et al.* 1974	Atlantic silverside		F	2500	24	50% mortality	Lethal	Artificial
Wilber and Clarke 2001	Cardwell *et al.* 1976	Pacific oyster larvae	L	I	2800	48	Abnormal shell development	Sublethal	Natural
Wilber and Clarke 2001	Sherk *et al.* 1974	White perch		F	2960	48	50% mortality	Lethal	Artificial
Wilber and Clarke 2001	Loosanoff 1962	Eastern oyster adult	A	I	3000	48	Reduced pumping	Sublethal	Natural
Wilber and Clarke 2001	Sherk *et al.* 1975	White perch		F	3050	24	10% mortality	Lethal	Artificial
Lunz 1987	Stern and Stickle 1978	White perch adult	A	F	3050	24	Not reported	N/AV	Artificial
Wilber and Clarke 2001	Sherk *et al.* 1974	Spot		F	3170	48	90% mortality	Lethal	Artificial
Wilber and Clarke 2001	Neumann *et al.* 1975	Oyster toadfish		F	3360	24	Oxygen consumption variable	Sublethal	Natural
Wilber and Clarke 2001	Boehlert 1984	Pacific herring larvae	L	F	4000	24	Punctured epidermis	Sublethal	Natural
Wilber and Clarke 2001	Loosanoff 1962	Eastern oyster adult	A	I	4000	48	Reduced pumping	Sublethal	Natural
Wilber and Clarke 2001	Peddicord 1980	Black-tailed sand shrimp		I	4300	72	5% mortality	Lethal	Natural
Wilber and Clarke 2001	Cardwell *et al.* 1976	Pacific oyster larvae	L	I	4400	48	No effect level	No Effect	Natural
Wilber and Clarke 2001	Sherk *et al.* 1975	Bay anchovy		F	4710	24	50% mortality	Lethal	Artificial
Lunz 1987	Morton 1977	Striped bass larvae	L	F	5210	72	Not reported	N/AV	Natural
Wilber and Clarke 2001	Cardwell *et al.* 1976	Pacific oyster larvae	L	I	5300	48	No effect level	No Effect	Natural
Lunz 1987	Morton 1977	White perch larvae	L	F	5380	72	Not reported	N/AV	Natural

Wilber and Clarke 2001	Cardwell *et al.* 1976	Pacific oyster larvae	L	I	5510	48	50% mortality	Lethal	Natural
Wilber and Clarke 2001	Cardwell *et al.* 1976	Pacific oyster larvae	L	I	7000	48	50% mortality	Lethal	Natural
Wilber and Clarke 2001	Cardwell *et al.* 1976	Pacific oyster larvae	L	I	9400	48	Abnormal shell development	Sublethal	Natural
Wilber and Clarke 2001	Sherk *et al.* 1974	Bay anchovy		F	9600	24	90% mortality	Lethal	Artificial
Wilber and Clarke 2001	Sherk *et al.* 1974	White perch		F	9850	24	50% mortality	Lethal	Artificial
Wilber and Clarke 2001	Sherk *et al.* 1974	White perch		F	9970	24	10% mortality	Lethal	Natural
Lunz 1987	Stern and Stickle 1978	White perch adult	A	F	9970	24	Not reported	N/AV	Natural
Clarke and Wilber 2000	Sherk *et al.* 1974 and 1975	Cusk eel adult	A	F	10000	24	10% mortality	Lethal	Artificial
Clarke and Wilber 2000	Sherk *et al.* 1974 and 1975	Hogchoker adult	A	F	10000	24	10% mortality	Lethal	Artificial
Clarke and Wilber 2000	Sherk *et al.* 1974 and 1975	Toadfish adult	A	F	10000	24	10% mortality	Lethal	Artificial
Wilber and Clarke 2001	Rogers 1969	Cunner		F	10000	24	50% mortality	Lethal	Natural
Wilber and Clarke 2001	Sherk *et al.* 1974	Atlantic silverside		F	10000	24	90% mortality	Lethal	Artificial
Wilber and Clarke 2001	Cardwell *et al.* 1976	Pacific oyster larvae	L	I	11700	48	Abnormal shell development	Sublethal	Natural
Wilber and Clarke 2001	Sherk *et al.* 1974	White perch		F	13060	48	90% mortality	Lethal	Artificial
Wilber and Clarke 2001	Sherk *et al.* 1974	Spot		F	13090	24	10% mortality	Lethal	Artificial
Wilber and Clarke 2001	Neumann *et al.* 1975	Oyster toadfish		F	14600	72	No effect level	No Effect	Natural
Lunz 1987	Stern and Stickle 1978	Spot adult	A	F	15090	24	Not reported	N/AV	Artificial
Wilber and Clarke 2001	Rogers 1969	Fourspine stickleback		F	18000	24	50% mortality	Lethal	Natural
Clarke and Wilber 2000	Messieh *et al.* 1981	Atlantic herring larvae	L	F	19000	48	100% Mortality	Lethal	Not Reported
Wilber and Clarke 2001	Sherk *et al.* 1974	White perch		F	19800	24	50% mortality	Lethal	Natural
Wilber and Clarke 2001	Sherk *et al.* 1974	Spot		F	20340	24	50% mortality	Lethal	Artificial
Wilber and Clarke 2001	Sherk *et al.* 1974	Striped killifish		F	23770	24	10% mortality	Lethal	Artificial
Lunz 1987	Stern and Stickle 1978	Striped killfish adult	A	F	23770	24	Not reported	N/AV	Artificial
Wilber and Clarke 2001	Sherk *et al.* 1974	Mummichog		F	24470	24	10% mortality	Lethal	Artificial
Lunz 1987	Stern and Stickle 1978	Mummichog adult	A	F	24470	24	Not reported	N/AV	Artificial
Wilber and Clarke 2001	Rogers 1969	Cunner		F	28000	24	50% mortality	Lethal	Natural
Wilber and Clarke 2001	Sherk *et al.* 1974	Spot		F	31620	24	90% mortality	Lethal	Artificial
Wilber and Clarke 2001	Sherk *et al.* 1974	White perch		F	31810	24	90% mortality	Lethal	Artificial
Wilber and Clarke 2001	Sherk *et al.* 1974	Mummichog		F	35860	48	10% mortality	Lethal	Artificial
Wilber and Clarke 2001	Sherk *et al.* 1974	Striped killifish		F	38190	24	50% mortality	Lethal	Artificial
Wilber and Clarke 2001	Sherk *et al.* 1974	Mummichog		F	39000	24	50% mortality	Lethal	Artificial
Wilber and Clarke 2001	Sherk *et al.* 1974	White perch		F	39400	24	90% mortality	Lethal	Natural
Wilber and Clarke 2001	Sherk *et al.* 1974	Mummichog		F	45160	48	50% mortality	Lethal	Artificial
Lunz 1987	Saile *et al.* 1968	Stickleback adult	A	F	52000	24	Not reported	N/AV	Natural
Wilber and Clarke 2001	Sherk *et al.* 1974	Mummichog		F	56890	48	90% mortality	Lethal	Artificial
Wilber and Clarke 2001	Sherk *et al.* 1974	Striped killifish		F	61360	24	90% mortality	Lethal	Artificial

Wilber and Clarke 2001	Sherk *et al.* 1974	Mummichog		F	62170	24	90% mortality	Lethal	Artificial
Wilber and Clarke 2001	Sherk *et al.* 1974	Spot		F	68750	24	10% mortality	Lethal	Natural
Lunz 1987	Stern and Stickle 1978	Spot adult	A	F	68750	24	Not reported	N/AV	Natural
Lunz 1987	Saile *et al.* 1968	Cunner adult	A	F	72000	48	Not reported	N/AV	Natural
Wilber and Clarke 2001	Sherk *et al.* 1974	Spot		F	88000	24	50% mortality	Lethal	Natural
Wilber and Clarke 2001	Sherk *et al.* 1975	Striped killifish		F	97200	24	10% mortality	Lethal	Natural
Lunz 1987	Stern and Stickle 1978	Striped killfish adult	A	F	97200	24	Not reported	N/AV	Natural
Lunz 1987	Saile *et al.* 1968	Cunner adult	A	F	100000	24	Not reported	N/AV	Natural
Lunz 1987	Saile *et al.* 1968	Cunner adult	A	F	100000	24	Not reported	N/AV	Natural
Wilber and Clarke 2001	Sherk *et al.* 1974	Spot		F	112630	24	90% mortality	Lethal	Natural
Wilber and Clarke 2001	Sherk *et al.* 1975	Striped killifish		F	128200	24	50% mortality	Lethal	Natural
Wilber and Clarke 2001	Rogers 1969	Cunner		F	133000	12	50% mortality	Lethal	Natural
Lunz 1987	Saile *et al.* 1968	Cunner adult	A	F	133000	12	Not reported	N/AV	Natural
Wilber and Clarke 2001	Sherk *et al.* 1974	Striped killifish		F	169300	24	90% mortality	Lethal	Natural
Wilber and Clarke 2001	Rogers 1969	Sheepshead minnow		F	200000	24	10% mortality	Lethal	Natural
Wilber and Clarke 2001	Rogers 1969	Fourspine stickleback		F	200000	24	95% mortality	Lethal	Natural
Wilber and Clarke 2001	Rogers 1969	Sheepshead minnow		F	300000	24	30% mortality	Lethal	Natural
Lunz 1987	Saile *et al.* 1968	Mummichog adult	A	F	300000	24	Not reported	N/AV	Natural
Lunz 1987	Saile *et al.* 1968	Sheepshead minnow adult	A	F	300000	24	Not reported	N/AV	Natural
Wilber and Clarke 2001	Murphy 1985	Northern quahog		I	6	336	No effect level	No Effect	Not Reported
Wilber and Clarke 2001	Bricelj *et al.* 1984	Northern quahog subadult	J	I	10	504	No effect level	No Effect	Natural
Wilber and Clarke 2001	Bricelj *et al.* 1984	Northern quahog subadult	J	I	25	504	No effect level	No Effect	Natural
Wilber and Clarke 2001	Murphy 1985	Northern quahog		I	27	336	Reduced growth	Sublethal	Not Reported
Wilber and Clarke 2001	Bricelj *et al.* 1984	Northern quahog subadult	J	I	44	504	No effect level	No Effect	Natural
Wilber and Clarke 2001	Nimmo *et al.* 1982	Mysid shrimp		I	45	96	No effect level	No Effect	Natural
Wilber and Clarke 2001	Nimmo *et al.* 1982	Mysid Shrimp		I	45	672	No effect level	No Effect	Natural
Wilber and Clarke 2001	Auld and Schubel 1978	American shad larvae	L	F	100	96	13% mortality	Lethal	Natural
Wilber and Clarke 2001	Grant and Thorpe 1991	Softshell clam		I	100	336	Amonia excretion increase	Sublethal	Natural
Clarke and Wilber 2000	Grant and Thorpe 1991	Softshell clam		I	100	360	Decreased stimulus response	Behavioral	Natural
Wilber and Clarke 2001	Davis and Hidu 1969	Eastern oyster larvae	L	I	100	288	No effect level	No Effect	Natural
Wilber and Clarke 2001	Davis and Hidu 1969	Northern quahog larvae	L	I	100	240	No effect level	No Effect	Natural
Wilber and Clarke 2001	Mackin 1961	Eastern oyster adult	A	I	100	504	No effect level	No Effect	Natural
Wilber and Clarke 2001	Robinson *et al.* 1984	Surf clam		I	100	504	No effect level	No Effect	Artificial
Wilber and Clarke 2001	Grant and Thorpe 1991	Softshell clam		I	100	504	Oxygen use decrease	Sublethal	Natural
Wilber and Clarke 2001	Grant and Thorpe 1991	Softshell clam		I	100	840	Reduced growth	Sublethal	Natural
Wilber and Clarke 2001	Lin *et al.* 1992	Kuruma shrimp subadult	J	I	180	504	10% mortality	Lethal	Natural

Wilber and Clarke 2001	Davis and Hidu 1969	Eastern oyster larvae	L	I	200	288	No effect level	No Effect	Natural
Wilber and Clarke 2001	Davis and Hidu 1969	Northern quahog larvae	L	I	200	240	No effect level	No Effect	Natural
Wilber and Clarke 2001	Mackin 1961	Eastern oyster adult	A	I	200	504	No effect level	No Effect	Natural
Wilber and Clarke 2001	Nimmo *et al.* 1982	Mysid shrimp		I	230	96	No effect level	No Effect	Natural
Wilber and Clarke 2001	Nimmo *et al.* 1982	Mysid shrimp		I	230	672	No effect level	No Effect	Natural
Wilber and Clarke 2001	Moore 1978	Bay scallop		I	250	168	No effect level	No Effect	Artificial
Wilber and Clarke 2001	Moore 1978	Bay scallop		I	250	336	No effect level	No Effect	Artificial
Wilber and Clarke 2001	Davis and Hidu 1969	Eastern oyster larvae	L	I	300	288	No effect level	No Effect	Natural
Wilber and Clarke 2001	Davis and Hidu 1969	Northern quahog larvae	L	I	300	240	No effect level	No Effect	Natural
Wilber and Clarke 2001	Mackin 1961	Eastern oyster adult	A	I	300	504	No effect level	No Effect	Natural
Wilber and Clarke 2001	Kiorboe *et al.* 1981	Atlantic herring eggs	E	F	300	264	Normal egg development level	Sublethal	Natural
Wilber and Clarke 2001	Lin *et al.* 1992	Kuruma shrimp subadult	J	I	370	504	32% mortality	Lethal	Natural
Wilber and Clarke 2001	Davis and Hidu 1969	Eastern oyster larvae	L	I	400	288	10% mortality	Lethal	Natural
Wilber and Clarke 2001	Davis and Hidu 1969	Northern quahog larvae	L	I	400	240	No effect level	No Effect	Natural
Wilber and Clarke 2001	Mackin 1961	Eastern oyster adult	A	I	400	504	No effect level	No Effect	Natural
Wilber and Clarke 2001	Davis and Hidu 1969	Eastern oyster larvae	L	I	500	288	18% mortality	Lethal	Natural
Wilber and Clarke 2001	Auld and Schubel 1978	Yellow perch larvae	L	F	500	96	30% mortality	Lethal	Natural
Wilber and Clarke 2001	Auld and Schubel 1978	American shad larvae	L	F	500	96	32% mortality	Lethal	Natural
Wilber and Clarke 2001	Moore 1978	Bay scallop		I	500	168	Higher respiration	Sublethal	Artificial
Wilber and Clarke 2001	Moore 1978	Bay scallop		I	500	336	Higher respiration	Sublethal	Artificial
Clarke and Wilber 2000	Auld and Schubel 1978	White perch larvae	L	F	500	96	Increased mortality	Lethal	Not Reported
Wilber and Clarke 2001	Davis and Hidu 1969	Northern quahog larvae	L	I	500	240	No effect level	No Effect	Natural
Wilber and Clarke 2001	Mackin 1961	Eastern oyster adult	A	I	500	504	No effect level	No Effect	Natural
Priest 981	Davis 1960	Hard clam larvae	L	I	500	288	Not reported	N/AV	Artificial
Wilber and Clarke 2001	Robinson *et al.* 1984	Surf clam		I	500	504	Reduced growth	Sublethal	Artificial
Wilber and Clarke 2001	Mackin 1961	Eastern oyster adult	A	I	590	480	No effect level	No Effect	Natural
Wilber and Clarke 2001	Sherk *et al.* 1974	Striped bass		F	600	264	No effect level	No Effect	Artificial
Wilber and Clarke 2001	Sherk *et al.* 1975	White perch		F	650	120	Increased hematocrit levels	Sublethal	Artificial
Wilber and Clarke 2001	Mackin 1961	Eastern oyster adult	A	I	710	480	No effect level	No Effect	Natural
Wilber and Clarke 2001	Davis and Hidu 1969	Northern quahog larvae	L	I	750	240	10% mortality	Lethal	Natural
Wilber and Clarke 2001	Davis and Hidu 1969	Eastern oyster larvae	L	I	750	288	30% mortality	Lethal	Natural
Clarke and Wilber 2000	Davis 1960	Hard clam larvae	L	I	750	288	Mortality	Lethal	Natural
Priest 1981	Davis and Hidu 1969	American oyster larvae	L	I	750	288	Mortality	Lethal	Natural
Wilber and Clarke 2001	Davis and Hidu 1969	Eastern oyster larvae	L	I	750	288	Reduced growth	Sublethal	Natural

Wilber and Clarke 2001	Sherk *et al.* 1974	Striped killifish		F	960	120	Increased hematocrit levels	Sublethal	Artificial
Wilber and Clarke 2001	Davis and Hidu 1969	Northern quahog larvae	L	I	1000	240	10% mortality	Lethal	Natural
Wilber and Clarke 2001	McFarland and Peddicord 1980	Shiner perch		F	1000	96	10% mortality	Lethal	Not Reported
Wilber and Clarke 2001	Wakeman *et al.* 1975	Black-tailed sand shrimp		I	1000	240	10% mortality	Lethal	Artificial
Wilber and Clarke 2001	Auld and Schubel 1978	American shad larvae	L	F	1000	96	29% mortality	Lethal	Natural
Wilber and Clarke 2001	Davis and Hidu 1969	Eastern oyster larvae	L	I	1000	288	40% mortality	Lethal	Natural
Wilber and Clarke 2001	Moore 1978	Bay scallop		I	1000	168	Higher respiration	Sublethal	Artificial
Wilber and Clarke 2001	Moore 1978	Bay scallop		I	1000	336	Higher respiration	Sublethal	Artificial
Wilber and Clarke 2001	Auld and Schubel 1978	Alewife eggs	E	F	1000	96	No effect level	No Effect	Natural
Wilber and Clarke 2001	Auld and Schubel 1978	American shad eggs	E	F	1000	96	No effect level	No Effect	Natural
Wilber and Clarke 2001	Auld and Schubel 1978	Blueback herring eggs	E	F	1000	96	No effect level	No Effect	Natural
Wilber and Clarke 2001	Auld and Schubel 1978	Yellow perch eggs	E	F	1000	96	No effect level	No Effect	Natural
Wilber and Clarke 2001	Auld and Schubel 1978	Striped bass eggs	E	F	1000	168	Reduced hatching success	Lethal	Natural
Wilber and Clarke 2001	Auld and Schubel 1978	White perch eggs	E	F	1000	168	Reduced hatching success	Lethal	Natural
Wilber and Clarke 2001	Nimmo *et al.* 1982	Mysid shrimp		I	1020	96	No effect level	No Effect	Natural
Wilber and Clarke 2001	Nimmo *et al.* 1982	Mysid shrimp		I	1020	672	No effect level	No Effect	Natural
Wilber and Clarke 2001	Wakeman *et al.* 1975	Striped bass larvae	L	F	1200	240	10% mortality	Lethal	Artificial
Wilber and Clarke 2001	Sherk *et al.* 1974	Hogchoker		F	1240	120	Increased hematocrit levels	Sublethal	Artificial
Wilber and Clarke 2001	Sherk *et al.* 1974	Spot		F	1270	120	No effect level	No Effect	Artificial
Wilber and Clarke 2001	Davis and Hidu 1969	Northern quahog larvae	L	I	1500	240	10% mortality	Lethal	Natural
Wilber and Clarke 2001	Davis and Hidu 1969	Eastern oyster larvae	L	I	1500	288	58% mortality	Lethal	Natural
Wilber and Clarke 2001	Sherk *et al.* 1974	Striped bass		F	1500	336	Increased hematocrit levels	Sublethal	Artificial
Wilber and Clarke 2001	Sherk *et al.* 1974	Mummichog		F	1620	96	Increased hematocrit levels	Sublethal	Artificial
Wilber and Clarke 2001	Peddicord 1980	Coast mussel		I	1900	480	No effect level	No Effect	Natural
Wilber and Clarke 2001	Davis and Hidu 1969	Northern quahog larvae	L	I	2000	240	10% mortality	Lethal	Natural
Wilber and Clarke 2001	Wakeman *et al.* 1975	Blue mussel		I	2000	240	10% mortality	Lethal	Artificial
Wilber and Clarke 2001	Davis and Hidu 1969	Eastern oyster larvae	L	I	2000	288	75% mortality	Lethal	Natural
Wilber and Clarke 2001	Peddicord 1976	Blue mussel		I	2000	480	No effect level	No Effect	Artificial
Priest 1981	Davis and Hidu 1969	American oyster larvae	L	I	2000	288	Not reported	N/AV	Artificial
Wilber and Clarke 2001	Peddicord 1980	Black-tailed sand shrimp		I	2500	504	No effect level	No Effect	Natural
Wilber and Clarke 2001	Davis and Hidu 1969	Northern quahog larvae	L	I	3000	240	15% mortality	Lethal	Natural

Wilber and Clarke 2001	Davis and Hidu 1969	Eastern oyster larvae	L	I	3000	288	99% mortality	Lethal	Natural
Lunz 1987	Priest 1981	Dungeness crab adult	A	I	3500	504	Not reported	N/AV	Natural
Wilber and Clarke 2001	McFarland and Peddicord 1980	Shiner perch		F	3600	96	20% mortality	Lethal	Not Reported
Wilber and Clarke 2001	Peddicord 1980	Coast mussel		I	3700	480	No effect level	No Effect	Natural
Wilber and Clarke 2001	Davis and Hidu 1969	Northern quahog larvae	L	I	4000	264	30% mortality	Lethal	Natural
Wilber and Clarke 2001	Peddicord 1976	Blue mussel		I	4000	480	No effect level	No Effect	Artificial
Lunz 1987	Priest 1981	Striped bass subadult	J	F	4000	504	Not reported	N/AV	Natural
Lunz 1987	Yagi *et al.* 1977	American oyster adult	A	I	4000	Not Reported	Not reported	N/AV	Not Reported
Wilber and Clarke 2001	McFarland and Peddicord 1980	Shiner perch		F	6000	96	50% mortality	Lethal	Not Reported
Wilber and Clarke 2001	Peddicord 1976	Blue mussel		I	8000	480	No effect level	No Effect	Artificial
Wilber and Clarke 2001	Peddicord 1980	Coast mussel		I	8100	408	10% mortality	Lethal	Natural
Wilber and Clarke 2001	Peddicord 1980	Black-tailed sand shrimp		I	8400	504	No effect level	No Effect	Natural
Wilber and Clarke 2001	Wakeman *et al.* 1975	Black-tailed sand shrimp		I	9000	240	10% mortality	Lethal	Artificial
Wilber and Clarke 2001	McFarland and Peddicord 197	Dungeness crab		I	9200	192	5% mortality	Lethal	Natural
Wilber and Clarke 2001	McFarland and Peddicord 1980	Dungeness crab		I	10000	192	10% mortality	Lethal	Artificial
Wilber and Clarke 2001	Wakeman *et al.* 1975	Blue mussel		I	10000	240	10% mortality	Lethal	Artificial
Wilber and Clarke 2001	McFarland and Peddicord 1980	Coast mussel		I	10000	240	20-40% mortality	Lethal	Artificial
Clarke and Wilber 2000	Grant and Thorpe 1991	Bivalves adult	A	I	10000	504	Mortality	Lethal	Natural
Nightingale *et al.* 2001	Ross 1982	Chinook salmon smolts	J	F	11000	96	50% mortality	Lethal	Not Reported
Wilber and Clarke 2001	Peddicord 1976	Blue mussel		I	11000	480	No effect level	No Effect	Artificial
Wilber and Clarke 2001	Peddicord 1980	Coast mussel subadult	J	I	11600	480	10% mortality	Lethal	Natural
Wilber and Clarke 2001	McFarland and Peddicord 197	Dungeness crab		I	11700	168	20% mortality	Lethal	Natural
Wilber and Clarke 2001	Peddicord 1980	Black-tailed sand shrimp		I	11900	120	10% mortality	Lethal	Natural
Wilber and Clarke 2001	Sherk *et al.* 1974	Spot		F	14680	168	No effect level	No Effect	Natural
Wilber and Clarke 2001	Peddicord 1976	Blue mussel		I	15000	192	0-20% mortality	Lethal	Artificial
Wilber and Clarke 2001	Peddicord 1980	Coast mussel subadult	J	I	15500	480	10% mortality	Lethal	Natural
Wilber and Clarke 2001	Peddicord 1980	Coast mussel subadult	J	I	15500	384	20-40% mortality	Lethal	Natural
Wilber and Clarke 2001	McFarland and Peddicord 197	Dungeness crab subadult	J	I	15900	216	15% mortality	Lethal	Natural
Wilber and Clarke 2001	McFarland and Peddicord 1980	Spot-tailed sand shrimp		I	16000	192	10% mortality	Lethal	Artificial
Wilber and Clarke 2001	McFarland and Peddicord 197	Dungeness crab subadult	J	I	18900	96	20% mortality	Lethal	Natural
Wilber and Clarke 2001	Peddicord 1976	Blue mussel		I	19000	480	No effect level	No Effect	Artificial
Wilber and Clarke 2001	Peddicord 1980	Coast mussel subadult	J	I	19500	480	10% mortality	Lethal	Natural

Lunz 1987	Priest 1981	Black-tailed shrimp subadu	J	I	21500	504	Not reported	N/AV	Natural
Wilber and Clarke 2001	McFarland and Peddicord 1980	Grass shrimp		I	24000	240	10% mortality	Lethal	Artificial
Wilber and Clarke 2001	McFarland and Peddicord 1980	Dungeness crab		I	32000	192	50% mortality	Lethal	Artificial
Lunz 1987	Yagi *et al.* 1977	American oyster adult	A	I	32000	Not Reported	Not reported	N/AV	Not Reported
Wilber and Clarke 2001	McFarland and Peddicord 1980	Spot-tailed sand shrimp		I	50000	192	50% mortality	Lethal	Artificial
Lunz 1987	Peddicord and McFarland 1978	Spot-tailed shrimp adult	A	I	50000	199.92	Not reported	N/AV	Artificial
Wilber and Clarke 2001	Wakeman *et al.* 1975	Blue mussel		I	60000	240	10% mortality	Lethal	Artificial
Wilber and Clarke 2001	McFarland and Peddicord 1980	Coast mussel		I	75000	144	20-40% mortality	Lethal	Artificial
Wilber and Clarke 2001	McFarland and Peddicord 1980	Grass shrimp		I	77000	192	20% mortality	Lethal	Artificial
Wilber and Clarke 2001	McFarland and Peddicord 1980	Coast mussel		I	80000	264	50% mortality	Lethal	Artificial
Wilber and Clarke 2001	McFarland and Peddicord 1980	Coast mussel		I	85000	216	50% mortality	Lethal	Artificial
Lunz 1987	Peddicord and McFarland 1978	Blue mussel adult	A	I	96000	199.92	Not reported	N/AV	Artificial
Wilber and Clarke 2001	McFarland and Peddicord 1980	Blue mussel		I	100000	264	10% mortality	Lethal	Artificial
Wilber and Clarke 2001	McFarland and Peddicord 1980	Blue mussel subadult	J	I	100000	120	10% mortality	Lethal	Artificial
White Paper Nightingale and Simenstad 2000		Crustaceans		I	100000	336	Mortality	Lethal	Not Reported
Lunz 1987	Peddicord and McFarland 1978	Blue mussel adult	A	I	100000	264	Not reported	N/AV	Artificial
White Paper Chiasson 1993		Rainbow smelt		F	10	Not Reported	Increased swimming behavior	Behavioral	Not Reported
Clarke and Wilber 2000	Urban and Kirchman 1992	American oyster subadult	J	I	20	Not Reported	Feeding effected	Sublethal	Artificial
Lunz 1987	Morton 1977	Striped Bass Eggs	E	F	20	Not Reported	Not reported	N/AV	Natural
Lunz 1987	Morton 1977	White Perch Eggs	E	F	30	Not Reported	Not reported	N/AV	Natural
Lunz 1987	Schubel *et al.* 1977	Alewife eggs	E	F	50	Not Reported	Not reported	N/AV	Natural
Lunz 1987	Schubel *et al.* 1977	Striped bass eggs	E	F	50	Not Reported	Not reported	N/AV	Natural
Lunz 1987	Schubel *et al.* 1977	White perch eggs	E	F	50	Not Reported	Not reported	N/AV	Natural
Lunz 1987	Schubel *et al.* 1977	Yellow perch eggs	E	F	50	Not Reported	Not reported	N/AV	Natural
Lunz 1987	Martin Marietta 1975	Eastern oyster adult	A	I	100	Not Reported	Not reported	N/AV	Natural
Priest 1981	Davis 1960	Hard clam eggs	E	I	125	Not Reported	Not reported	N/AV	Artificial
Priest 1981	Davis 1960	Hard clam eggs	E	I	125	Not Reported	Not reported	N/AV	Artificial
Clarke and Wilber 2000	Davis and Hidu 1969	American oyster eggs	E	I	188	Not Reported	Development effected	Sublethal	Natural

Priest 1981	Davis and Hidu 1969	American oyster eggs	E	I	250	Not Reported	Not reported	N/AV	Natural
Priest 1981	Davis and Hidu 1969	American oyster eggs	E	I	375	Not Reported	Not reported	N/AV	Natural
Priest 1981	Davis and Hidu 1969	American oyster larvae	L	I	500	Not Reported	Not reported	N/AV	Artificial
Lunz 1987	Schubel *et al.* 1977	Alewife eggs	E	F	500	Not Reported	Not reported	N/AV	Natural
Lunz 1987	Schubel *et al.* 1977	Striped bass eggs	E	F	500	Not Reported	Not reported	N/AV	Natural
Lunz 1987	Schubel *et al.* 1977	White perch eggs	E	F	500	Not Reported	Not reported	N/AV	Natural
Lunz 1987	Schubel *et al.* 1977	Yellow perch eggs	E	F	500	Not Reported	Not reported	N/AV	Natural
Lunz 1987	Martin Marietta 1975	Eastern oyster adult	A	I	700	Not Reported	Not reported	N/AV	Natural
Priest 1981	Davis 1960	Hard clam eggs	E	I	750	Not Reported	Development effected	Sublethal	Natural
White Paper Mulholland 1983		Hard clams eggs	E	I	1000	Not Reported	Development effects	Sublethal	Not Reported
Priest 1981	Davis and Hidu 1969	American oyster eggs	E	I	1000	Not Reported	Not reported	N/AV	Artificial
Priest 1981	Davis 1960	Hard clam eggs	E	I	1500	Not Reported	Not reported	N/AV	Natural
Priest 1981	Davis and Hidu 1969	American oyster eggs	E	I	2000	Not Reported	Not reported	N/AV	Artificial
Lunz 1987	Morton 1977	Striped bass eggs	E	F	2300	Not Reported	Not reported	N/AV	Natural
White Paper Nightingale and Simenstad 2000		Fish		F	4000	Not Reported	Erosion at gill filament tips	Sublethal	Not Reported
Priest 1981 Davis and Hidu 1969		Hard clam eggs	E	I	4000	Not Reported	Not reported	N/AV	Artificial
Lunz 1987 Morton 1977		White perch eggs	E	F	5000	Not Reported	Not reported	N/AV	Natural
Clarke and Wilber 2000	Messieh *et al.* 1981	Atlantic herring eggs	E	F	7000	Not Reported	No Effect	No Effect	Not Reported
Lunz 1987	Schreck 1981	American lobster adult	A	I	50000	Not Reported	Not reported	N/AV	Artificial
Murphy 1985		Northern quahog		I	6	336	No effect	No Effect	Not Reported
MacKinley *et al.* 1987		Salmon (Chinook) juvenile	J	F	6	1440	Reduced growth rate	Sublethal	Not Reported
Bricelj *et al.* 1984 (ns)		Northern quahog larvae	L	I	10	504	No effect	No Effect	Natural
Johnson and Wildish 1982		Herring larvae	L	F	10	3	Depth preference changed	Behavioral	Not Reported
Townsend 1983; Ott 1984		Salmon adult	A	F	16	24	Reduced feeding activity	Sublethal	Not Reported
Senson and Matson 1976		Herring (lake) larvae	L	F	16	24	Depth preference changed	Behavioral	Not Reported
Servizi and Martens 1992		Salmon (coho)		F	20	0.05	Cough frequency not increased	No Effect	Fine Natural

Johnson and Wildish 1982		Herring (Atlantic) adult	A	F	20	3	Reduced feeding rate	Sublethal	Not Reported
Bricelj *et al.* 1984 (ns)		Northern quahog larvae	L	I	25	504	No effect	No Effect	Natural
Noggle 1978		Salmon (coho) juvenile	J	F	25	1	Reduced feeding rate	Sublethal	Not Reported
Phillips 1970		Salmon adult	A	F	25	4	Reduced feeding activity	Sublethal	Not Reported
Murphy 1985		Northern quahog		I	27	336	Reduced growth	Sublethal	Not Reported
Bricelj *et al.* 1984 (ns)		Northern quahog larvae	L	I	44	504	Reduced growth	Sublethal	Natural
Nimmo *et al.* 1982 (ns)		Mysid shrimp		I	45	96	No effect	No Effect	Natural
Nimmo *et al.* 1982 (ns)		Mysid shrimp		I	45	672	No effect	No Effect	Natural
Berg and Northcote 1985		Salmon (coho) juvenile	J	F	54	12	Increased physiological stress	Sublethal	Natural fines
Berg 1983		Salmon (coho) juvenile	J	F	54	0.02	Alarm reaction	Behavioral	
Berg and Northcote 1985		Salmon (coho) juvenile	J	F	54	12	Changes in territorial behavior	Behavioral	Natural fines
Huntington and Miller 1989		Northern quahog		I	56	24	No effect	No Effect	
Huntington and Miller 1989		Northern quahog		I	56	48	No effect	No Effect	
Huntington and Miller 1989		Northern quahog		I	56	12	No effect	No Effect	
Sherk *et al.* 1975		Silverside (Atlantic) adult	A	F	58	24	10% mortality rate (FE)	Lethal	
Buck 1956		Bass (largemouth) adult	A	F	62	720	Weight gain reduced-50%	Sublethal	
Slaney *et al.* 1977b		Salmon adult	A	F	75	168	Reduced quality of rearing habitat	Sublethal	
Bisson and Bilby 1982		Salmon (coho) juvenile	J	F	88	0.02	Alarm reaction	Behavioral	
Bisson and Bilby 1982		Salmon (coho) juvenile	J	F	88	0.08	Avoidance behavior	Behavioral	
Noggle 1978		Salmon (coho) juvenile	J	F	100	1	Feeding rate decreased to 55% of maximum	Sublethal	
Davis and Hidu 1969 (s)		Northern quahog		I	100	240	No effect	No Effect	
Grant and Thorpe 1991 (ns)		Softshell clam		I	100	840	Reduced growth	Sublethal	Natural
Auld and Schubel 1978	Morgan *et al.* (1973)	American shad larvae	L	F	100	96	13% mortality	Lethal	Natural fine-grained clay
Auld and Schubel 1978	Morgan *et al.* (1973)	Shad (American) larvae	L	F	100	96	18% mortality rate (controls, 5%)	Lethal	Natural fine-grained clay
Schubel and Wang 1973		White perch eggs	E	F	100	24	Hatching delayed	Sublethal	Not Reported
Davis and Hidu 1969 (s)		Eastern oyster		I	100	288	No effect	No Effect	silt
Turner and Miller 1991 (ns)		Northern quahog		I	100	48	Reduced growth	Sublethal	Natural sediment
Robinson *et al.* 1984 (ac)		Surf clam		I	100	72	No effect	No Effect	attapulgite clay
Schubel and Wang 1973		Bass (striped) eggs	E	F	100	24	Delayed hatching	Sublethal	Not Reported
Mackin 1961 (ns)		Eastern oyster		I	100	504	No effect	No Effect	Natural

Grant and Thorpe 1991 (ns)		Softshell clam		I	100	336	NH4 excretion up	Sublethal	Natural
Grant and Thorpe 1991 (ns)		Softshell clam		I	100	504	O2 consumption down	Sublethal	Natural
Robinson *et al.* 1984 (ac)		Surf clam		I	100	504	No effect	No Effect	Artificial clay
Sigler *et al.* 1984		steelhead juvenile	J	F	102	336	Reduced growth rate	Sublethal	Not Reported
Sigler *et al.* 1984		Salmon (coho) juvenile	J	F	102	336	Reduced growth rate	Sublethal	Not Reported
Huntington and Miller 1989		Northern quahog		I	110	48	No effect	No Effect	Not Reported
Huntington and Miller 1989		Northern quahog		I	110	12	No effect	No Effect	Not Reported
Huntington and Miller 1989		Northern quahog		I	110	24	No effect	No Effect	Not Reported
Turner and Miller 1991 (ns)		Northern quahog		I	120	48	Reduced growth	Sublethal	Natural
Buck 1956		Bass (largemouth) adult	A	F	144	720	Growth retarded	Sublethal	Not Reported
Buck 1956		Bass (largemouth) adult	A	F	144	720	Fish unable to reproduce	Sublethal	Not Reported
Dadswell *et al.* 1983		Shad (American) adult	A	F	150	0.25	Change in preferred swimming depth	Behavioral	Not Reported
Morgan *et al.* 1973		White perch larvae	L	F	155	48	50% mortality	Lethal	Not Reported
Lin *et al.* 1992 (ns)		Kuruma shrimp		I	180	504	10% mortality	Lethal	Natural
Turner and Miller 1991 (ns)		Northern quahog		I	193	48	Reduced growth	Sublethal	Natural
Davis and Hidu 1969 (s)		Eastern oyster		I	200	288	No effect	No Effect	silt
Breitburg 1988		Bass (striped) larvae	L	F	200	0.42	Reduced feeding rate	Sublethal	kaolin
Mackin 1961 (ns)		Eastern oyster		I	200	504	No effect	No Effect	Natural
Breitburg 1988 (k)		Striped bass larvae	L	F	200	24	Reduced feeding rate	Sublethal	kaolin
Davis and Hidu 1969 (s)		Northern quahog		I	200	240	No effect	No Effect	silt
Hamilton 1961		Salmon adult	A	F	210	24	Fish abandoned their traditional spawning habitat	Behavioral	Not Reported
Huntington and Miller 1989		Northern quahog		I	220	24	No effect	No Effect	Not Reported
Huntington and Miller 1989		Northern quahog		I	220	48	No effect	No Effect	Not Reported
Huntington and Miller 1989		Northern quahog		I	220	12	No effect	No Effect	Not Reported
Nimmo *et al.* 1982 (ns)		Mysid shrimp		I	230	96	No effect	No Effect	Natural
Nimmo *et al.* 1982 (ns)		Mysid shrimp		I	230	672	40% mortality	Lethal	Natural
Sherk *et al.* 1975		Anchovy (bay) adult	A	F	2310	24	10% mortality rate (FE)	Lethal	Fuller's earth
Servizi and Martens 1992	SAS Institute Inc. 1985	Salmon (coho)		F	240	24	Cough frequency increased more than 5-fold	Sublethal	Natural fines
Sherk *et al.* 1975		Silverside (Atlantic) adult	A	F	2500	24	50%mortality rate (FE)	Lethal	Fuller's earth
Moore 1978 (k)		Bay scallop		I	250	168	No effect	No Effect	kaolin
Noggle 1978		Salmon (coho) juvenile	J	F	250	1	Feeding rate decreased to 10% of maximum	Sublethal	Not Reported

Moore 1978 (k)		Bay scallop		I	250	336	No effect	No Effect	kaolin
Mackin 1961 (ns)		Eastern oyster		I	300	504	No effect	No Effect	Natural
Kiorboe *et al.* 1981 b (ns)		Atlantic herring eggs	E	F	300	264	Normal egg development	No Effect	Natural silt (incl. mud from a soft bottom)
Davis and Hidu 1969 (s)		Eastern oyster		I	300	288	No effect	No Effect	silt
Davis and Hidu 1969 (s)		Northern quahog		I	300	240	No effect	No Effect	silt
Servizi and Martens 1992		Salmon (coho)		F	300	0.17	Avoidance behavior within minutes	Behavioral	Natural fine
Noggle 1978		Salmon (coho) juvenile		F	300	1	Feeding ceased	Sublethal	Not Reported
Whitman *et al.* 1982		Salmon (Chinook) adult	A	F	350	0.17	Home water preference disrupted	Behavioral	Not Reported
Lin *et al.* 1992 (ns)		Kuruma shrimp larvae	L	I	370	504	32% mortality	Lethal	Natural
Morgan *et al.* 1973		White perch larvae	L	F	373	24	50% mortality	Lethal	Not Reported
Davis and Hidu 1969 (s)		Northern quahog		I	400	240	No effect	No Effect	silt
Mackin 1961 (ns)		Eastern oyster		I	400	504	No effect	No Effect	Natural
Davis and Hidu 1969 (s)		Eastern oyster		I	400	288	10% mortality	Lethal	silt
Sherk *et al.* 1975		Anchovy (bay) adult	A	F	4710	24	50% mortality rate (FE)	Lethal	Fuller's earth
Morgan *et al.* 1973		Striped bass larvae	L	F	485	24	50% mortality	Lethal	Not Reported
Morgan *et al.* 1973		Bass (striped) larvae	L	F	485	24	50% mortality rate	Lethal	Not Reported
Stober *et al.* 1981		Salmon (Chinook) spawning		F	488	96	50% mortality	Lethal	Not Reported
Davis and Hidu 1969 (s)		Eastern oyster		I	500	288	18% mortality	Lethal	silt
Redding and Schreck 1982		Steelhead adult	A	F	500	9	Blood cell count & blood chemistry change	Sublethal	Not Reported
Robinson *et al.* 1984 (ac)		Surf clam		I	500	72	No effect	No Effect	attapulgite clay
Davis and Hidu 1969 (s)		Northern quahog		I	500	240	No effect	No Effect	silt
Auld and Schubel 1978	Morgan *et al.* (1973)	Yellow perch larvae	L	F	500	96	30% mortality	Lethal	Natural fine-grained clay
Auld and Schubel 1978	Morgan *et al.* (1973)	Shad (American) larvae	L	F	500	96	36% mortality rate (controls, 4%)	Lethal	Natural fine-grained clay
Robinson *et al.* 1984 (ac)		Surf clam		I	500	504	Reduced growth	Sublethal	attapulgite clay
Moore 1978 (k)		Bay scallop		I	500	168	Higher respiration	Sublethal	kaolin
Moore 1978 (k)		Bay scallop		I	500	336	Higher respiration	Sublethal	kaolin
Auld and Schubel 1978	Morgan *et al.* (1973)	American shad		F	500	96	32% mortality	Lethal	Natural fine-grained clay
Auld and Schubel 1978	Morgan *et al.* (1973)	Bass (striped) larvae	L	F	500	72	42% mortality rate (controls, 17%)	Lethal	Natural fine-grained clay
Breitburg 1988 (k)		Striped bass larvae	L	F	500	24	Reduced feeding rate	Sublethal	kaolin
Auld and Schubel 1978 (ns)		Striped bass larvae	L	F	500	72	Increased mortality	Lethal	Natural fine-grained clay
Redding and Schreck 1982		Steelhead adult	A	F	500	3	Signs of sublethal stress	Sublethal	Not Reported
Mackin 1961 (ns)		Eastern oyster		I	500	504	No effect	No Effect	Natural

Kiorboe *et al.* 1981 b (ns)		Atlantic herring eggs	E	F	500	24	Normal egg development	No Effect	Natural silt (incl. mud from a soft bottom)
Stober *et al.* 1981		Salmon (coho) spawning	A	F	509	96	50% mortality	Lethal	Not Reported
Griffin 1938		Salmon (Pacific) adult	A	F	525	588	No mortality	No Effect	Not Reported
Servizi and Martens 1992		Salmon (coho)		F	530	96	Blood glucose levels increased	Sublethal	Fine Natural
Huntington and Miller 1989		Northern quahog		I	560	12	No effect	No Effect	Not Reported
Huntington and Miller 1989		Northern quahog		I	560	24	No effect	No Effect	Not Reported
Huntington and Miller 1989		Northern quahog		I	560	48	No effect	No Effect	Not Reported
Mackin 1961 (ns)		Eastern oyster		I	590	480	No effect	No Effect	Natural sediment
Sherk *et al.* 1974 (fe)		Striped bass		F	600	264	No effect	No Effect	Artificial
Whitman *et al.* 1982		Salmon (Chinook) adult	A	F	650	168	Homing behavior normal, but fewer test fish returned	Behavioral	Not Reported
Brannon *et al.* 1981		Salmon (Chinook) adult	A	F	650	168	No histological signs of damage to olfactory epithelium	No Effect	Not Reported
Mackin 1961 (ns)		Eastern oyster		I	710	480	No effect	No Effect	Natural
Davis and Hidu 1969 (s)		Eastern oyster		I	750	288	30% mortality	Lethal	silt
Davis and Hidu 1969 (s)		Eastern oyster		I	750	288	Reduced growth	Sublethal	silt
Davis and Hidu 1969 (s)		Northern quahog		I	750	240	10% mortality	Lethal	silt
Morgan *et al.* 1983		Bass (striped) eggs	E	F	800	24	Development rate slowed significantly	Sublethal	Not Reported
Morgan *et al.* 1983 (ns)		Striped bass eggs	E	F	800	24	Development slowed	Sublethal	Natural
Stober *et al.* 1981		Salmon (Chinook) spawning	A	F	943	72	Reduced tolerance to stress	Sublethal	Not Reported
Sherk *et al.* 1975		Anchovy (bay) adult	A	F	960	24	90% mortality rate	Lethal	Not Reported
Auld and Schubel 1978	Morgan *et al.* (1973)	Blueback herring eggs	E	F	1000	96	No effect	No Effect	Natural fine-grained clay
Davis and Hidu 1969 (s)		Northern quahog		I	1000	240	10% mortality	Lethal	
Moore 1978 (k)		Bay scallop		I	1000	336	Higher respiration	Sublethal	Artificial, kaolin
Loosanoff 1962 (ns)		Eastern oyster		I	1000	24	Reduced pumping	Sublethal	Natural
Auld and Schubel 1978	Morgan *et al.* (1973)	Alewife eggs	E	F	1000	96	No effect	No Effect	Natural fine-grained clay
Davis and Hidu 1969 (s)		Eastern oyster		I	1000	288	40% mortality	Lethal	
McFarland and Peddicord 1980		Shiner perch		F	1000	96	10% mortality	Lethal	

Auld and Schubel 1978 (ns)	Morgan *et al.* (1973)	Striped bass larvae	L	F	1000	72	Increased mortality	Lethal	Natural fine-grained clay
Auld and Schubel 1978	Morgan *et al.* (1973)	Shad (American) larvae	L	F	1000	96	34% mortality rate (controls, 5%)	Lethal	Natural fine-grained clay
Boehlert 1984		Herring (Pacific)		F	1000	24	Mechanical damage to epidermis	Sublethal	
Auld and Schubel 1978	Morgan *et al.* (1973)	Bass (striped) larvae	L	F	1000	68	35% mortality rate (controls, 17%)	Lethal	Natural fine-grained clay
Auld and Schubel 1978	Morgan *et al.* (1973)	Bass (striped) eggs	E	F	1000	168	Reduced hatching success	Sublethal	Natural fine-grained clay
Sherk *et al.* 1975		Silverside (Atlantic) adult	A	F	1000	24	90% mortality rate (FE)	Lethal	
Auld and Schubel 1978 (ns)	Morgan *et al.* (1973)	Striped bass eggs	E	F	1000	168	Reduced hatching success	Lethal	Natural fine-grained clay
Auld and Schubel 1978	Morgan *et al.* (1973)	American shad eggs	E	F	1000	96	No effect	No Effect	Natural fine-grained clay
Wakeman *et al.* 1975 (b)		Black-tailed sand shrimp		I	1000	240	10% mortality	Lethal	Artificial, bentonite
Boehlert 1984 (ns)		Pacific herring larvae	L	F	1000	24	Damage to epidermis	Sublethal	Natural sediment
Moore 1978 (k)		Bay scallop		I	1000	168	Higher respiration	Sublethal	Artificial, kaolin
Robinson *et al.* 1984 (ac)		Surf clam		I	1000	72	No effect	No Effect	Artificial
Auld and Schubel 1978	Morgan *et al.* (1973)	Yellow perch eggs	E	F	1000	96	No effect	No Effect	Natural fine-grained clay
Auld and Schubel 1978	Morgan *et al.* (1973)	White perch eggs	E	F	1000	168	Reduced hatching success	Sublethal	Natural fine-grained clay
Auld and Schubel 1978	Morgan *et al.* (1973)	American shad		F	1000	96	29% mortality	Lethal	Natural fine-grained clay
Nimmo *et al.* 1982 (ns)		Mysid shrimp		I	1020	672	60-80% mortality	Lethal	Natural
Nimmo *et al.* 1982 (ns)		Mysid shrimp		I	1020	96	No effect	No Effect	Natural
Wakeman *et al.* 1975 (b)		Striped bass larvae	L	F	1200	240	10% mortality	Lethal	bentonite
Noggle 1978		Salmon (coho) juvenile	J	F	1200	96	50% mortality	Lethal	Not Reported
Stober *et al.* 1981		Salmon (coho) spawning	A	F	1217	96	50% mortality	Lethal	Not Reported
Newcomb and Flagg 1983		Salmon (Chinook) juvenile	J	F	1400	36	50% mortality	Lethal	Not Reported
Sherk *et al.* 1974 (fe)		Striped bass		F	1500	336	Hematocrit increased	Sublethal	Fuller's earth
Davis and Hidu 1969 (s)		Northern quahog		I	1500	240	10% mortality	Lethal	silt
Sherk *et al.* 1975		Bass (striped) adult	A	F	1500	336	Haematocrit increased (FE)	Sublethal	Not Reported
Davis and Hidu 1969 (s)		Eastern oyster		I	1500	288	58% mortality	Lethal	silt
Sherk *et al.* 1975		Bass (striped) adult	A	F	1500	336	Plasma osmolality increased (FE)	Sublethal	Not Reported
Noggle 1978		Salmon (coho) juvenile	J	F	1547	96	Gill damage	Sublethal	Not Reported
Coats *et al.* 1985		Steelhead adult	A	F	1650	240	Loss of habitat caused by excessive sediment transport	Sublethal	Not Reported

Coats *et al.* 1985		Salmon adult	A	F	1650	240	Loss of habitat caused by excessive sediment transport	Sublethal	Not Reported
Peddicord 1980 (ns)		Coast mussels		I	1900	480	No effect	No Effect	Natural fine clay
Boehlert and Morgan 1985		Pacific herring larvae	L	F	2000	24	Reduced feeding rate	Sublethal	Not Reported
Loosanoff 1962 (ns)		Eastern oyster		I	2000	24	Reduced pumping	Sublethal	Natural
Davis and Hidu 1969 (s)		Northern quahog		I	2000	240	10% mortality	Lethal	silt
Peddicord 1976 (k)		Blue mussel		I	2000	480	No effect	No Effect	kaolin
Wakeman *et al.* 1975 (b)		Blue mussel adult	A	I	2000	240	10% mortality	Lethal	bentonite
Boehlert and Morgan 1985		Herring (Pacific) larvae	L	F	2000	2	Reduced feeding rate	Sublethal	Not Reported
Davis and Hidu 1969 (s)		Eastern oyster		I	2000	288	75% mortality	Lethal	silt
Huntington and Miller 1989		Northern quahog		I	2200	12	No effect	No Effect	Not Reported
Huntington and Miller 1989		Northern quahog		I	2200	48	Reduced growth	Sublethal	Not Reported
Huntington and Miller 1989		Northern quahog		I	2200	24	No effect	No Effect	Not Reported
Sherk *et al.* 1975 (fe)		Bay anchovy		F	2310	24	10% mortality	Lethal	Fuller's earth
Servizi and Martens 1992		Salmon (coho)		F	2460	24	Fatigue of the cough reflex	Sublethal	Natural fines
Servizi and Martens 1992		Salmon (coho)		F	2460	1	Cough frequency greatly increased	Sublethal	Natural fines
Servizi and Martens 1992		Salmon (coho)		F	2460	0.05	Coughing behavior manifest within minutes	Sublethal	Natural fines
Gibson 1933		Salmon (Atlantic) adult	A	F	2500	24	Increased risk of predation	Behavioral	Not Reported
Peddicord 1980 (ns)		Black-tailed sand shrimp		I	2500	504	No effect	No Effect	Natural fine clay
Servizi and Martens 1992		Salmon (coho)		F	3000	48	High level sublethal stress; avoidance	Sublethal	Natural fines
Davis and Hidu 1969 (s)		Eastern oyster		I	3000	288	99% mortality	Lethal	silt
Loosanoff 1962 (ns)		Eastern oyster		I	3000	24	Reduced pumping	Sublethal	Natural
Davis and Hidu 1969 (s)		Northern quahog		I	3000	240	15% mortality	Lethal	silt
McFarland and Peddicord 1980		Shiner perch		F	3600	96	20% mortality	Lethal	Natural fine clay
Peddicord 1980 (ns)		Coast mussels		I	3700	480	No effect	No Effect	Natural fine clay
Boehlert 1984		Herring (Pacific) larvae	L	F	4000	24	Epidermis punctured; microridges less distinct	Sublethal	Not Reported
Davis and Hidu 1969 (s)		Northern quahog		I	4000	264	30% mortality	Lethal	silt
Boehlert 1984 (ns)		Pacific herring larvae	L	F	4000	24	Epidermis punctured	Sublethal	Natural
Peddicord 1976 (k)		Blue mussel		I	4000	480	No effect	No Effect	kaolin
Loosanoff 1962 (ns)		Eastern oyster		I	4000	48	Reduced pumping	Sublethal	Natural
Peddicord 1980 (ns)		Black-tailed sand shrimp		I	4300	72	5% mortality	Lethal	Natural fine clay

Sherk *et al.* 1975 (fe)		Bay anchovy		F	4710	24	50% mortality	Lethal	Fuller's earth
Noggle 1978		Salmon (coho) juvenile	J	F	6000	1	Avoidance behavior	Sublethal	Not Reported
McFarland and Peddicord 1980		Shiner perch		F	6000	96	50% mortality	Lethal	Natural clay
Peddicord 1976 (k)		Blue mussel		I	8000	480	No effect	No Effect	kaolin
Servizi and Martens 1991		Salmon (coho)		F	8000	96	1% mortality	Lethal	Natural fines
Peddicord 1980 (ns)		Coast Mussels		I	8100	408	10% mortality	Lethal	Natural clay
Servizi and Martens 1991		Salmon (coho)		F	8100	96	50% mortality	Lethal	Natural fines
Peddicord 1980 (ns)		Black-tailed sand shrimp		I	8400	504	No effect	No Effect	Natural clay
Wakeman *et al.* 1975 (b)		Black-tailed sand shrimp		I	9000	240	10% mortality	Lethal	bentonite
Peddicord and McFarland 1976 (ns)		Dungeness crab		I	9200	192	5% mortality	Lethal	Natural
Newcomb and Flagg 1983		Salmon (Chinook) juvenile	J	F	9400	36	50% mortality	Lethal	volcanic ash
Sherk *et al.* 1974 (fe)		Bay anchovy		F	9600	24	90% mortality	Lethal	Fuller's earth
Wakeman *et al.* 1975 (b)		Blue mussel adult	A	I	10000	240	10% mortality	Lethal	bentonite
McFarland and Peddicord 1980 (k)		Dungeness crab adult	A	I	10000	192	10% mortality	Lethal	kaolin
McFarland and Peddicord 1980 (k)		Coast Mussels adult	A	I	10000	240	20-40% mortality	Lethal	kaolin
Stober *et al.* 1981		Salmon (Chinook) spawning	A	F	11000	96	50% mortality	Lethal	Salmon (Chinook) spawning
Peddicord 1976 (k)		Blue mussel		I	11000	480	No effect	No Effect	kaolin
Peddicord 1980 (ns)		Coast Mussels larvae	L	I	11600	480	10% mortality	Lethal	Natural fine clay
Peddicord and McFarland 1976 (ns)		Dungeness crab		I	11700	168	20% mortality	Lethal	Natural fine clay
Peddicord 1980 (ns)		Black-tailed sand shrimp		I	11900	120	10% mortality	Lethal	Natural fine clay
Peddicord 1976 (k)		Blue mussel		I	15000	192	0-20% mortality	Lethal	kaolin
Peddicord 1980 (ns)		Coast Mussels larvae	L	I	15500	240	10% mortality	Lethal	Natural fine clay
Peddicord 1980 (ns)		Coast Mussels larvae	L	I	15500	384	20-40% mortality	Lethal	Natural fine clay
Peddicord and McFarland 1976 (ns)		Dungeness crab larvae	L	I	15900	216	15% mortality	Lethal	Natural fine clay
McFarland and Peddicord 1980 (k)		Spot-tailed sand shrimp		I	16000	192	10% mortality	Lethal	Natural fine clay
Stober *et al.* 1981		Salmon (coho) post spawning	A	F	18672	96	50% mortality	Lethal	Not Reported
Peddicord and McFarland 1976 (ns)		Dungeness crab larvae	L	I	18900	96	20% mortality	Lethal	Natural fine clay
Peddicord 1976 (k)		Blue mussel		I	19000	480	No effect	No Effect	kaolin
Stober *et al.* 1981		Salmon (Chinook) spawning	A	F	19354	96	50% mortality	Lethal	Not Reported
Peddicord 1980 (ns)		Coast mussels larvae	L	I	19500	480	10% mortality	Lethal	Natural fine clay
Servizi and Martens 1991		Salmon (coho)		F	22700	96	50% mortality	Lethal	Natural

McFarland and Peddicord 1980 (k)		Grass shrimp		I	24000	240	10% mortality	Lethal	kaolin
Wallen 1951		Carp (common) adult	A	F	25000	336	Some mortality (MC)	Lethal	Not Reported
Smith 1940		Salmon (chum) juvenile	J	F	28000	96	50% mortality	Lethal	Not Reported
Stober *et al.* 1981		Salmon (coho) spawning	A	F	28184	96	50% mortality	Lethal	Not Reported
Stober *et al.* 1981		Salmon (coho) spawning	A	F	29580	96	50% mortality	Lethal	Not Reported
McFarland and Peddicord 1980 (k)		Dungeness crab adult	A	I	32000	192	50% mortality	Lethal	kaolin
Noggle 1978		Salmon (coho) juvenile	J	F	35000	96	50% mortality	Lethal	Not Reported
Newcomb and Flagg 1983		Salmon (Chinook) adult	A	F	39300	24	No mortality	No Effect	volcanic ash
Newcomb and Flagg 1983		Salmon (Chinook) juvenile	J	F	39400	36	90% mortality	Lethal	volcanic ash
McFarland and Peddicord 1980 (k)		Spot-tailed sand shrimp		I	50000	192	50% mortality	Lethal	kaolin
Smith 1940		Salmon (chum) juvenile	J	F	55000	96	50% mortality	Lethal	bentonite
Wakeman *et al.* 1975 (b)		Blue mussel adult	A	I	60000	240	10% mortality	Lethal	bentonite
McFarland and Peddicord 1980 (k)		Coast mussels adult	A	I	75000	144	20-40% mortality	Lethal	kaolin
McFarland and Peddicord 1980 (k)		Grass shrimp		I	77000	192	20% mortality	Lethal	kaolin
McFarland and Peddicord 1980 (k)		Coast mussels adult	A	I	80000	164	50% mortality	Lethal	kaolin
Newcomb and Flagg 1983		Salmon (Chinook) adult	A	F	82400	6	60% mortality	Lethal	volcanic ash
McFarland and Peddicord 1980 (k)		Coast mussels adult	A	I	85000	216	50% mortality	Lethal	kaolin
McFarland and Peddicord 1980 (k)		Blue mussel larvae	L	I	100000	120	10% mortality	Lethal	kaolin
McFarland and Peddicord 1980 (k)		Blue mussel adult	A	I	100000	264	10% mortality	Lethal	kaolin
Newcomb and Flagg 1983		Salmon (Chinook) adult	A	F	207000	1	100% mortality	Lethal	volcanic ash

APPENDIX I

Common and Scientific Names of Fish

Fishes found in the San Francisco Bay-Delta estuary.[(a)]

Class	Order	Family	Genus/Species	Common Name
Agnatha	Petromyzontiformes	Petromyzontidae	Lampetra (=Entosphenus) tridentata	Pacific lamprey
			Lampetra ayresi	River lamprey
Chondrichthyes	Hexanchiformes	Hexanchidae	Notorynchus maculatus	Sevengill shark
			Hexanchus griseus	Sixgill shark
	Squaliformes	Carcharhinidae	Mustelus henlei	Brown smoothhound
			Mustelus californicus	Gray smoothhound
			Triakis semifasciata	Leopard shark
			Galeorhinus zyopterus	Soupfin shark
		Squalidae	Squalus acanthias	Spiny dogfish
		Alipiidae	Alopias vulpinus	Common thresher
	Rajiformes	Torpedinidae	Torpedo californica	Pacific electric ray
		Rijidae	Raja binoculata	Big skate
		Myliobatidae	Myliobatis californica	Bat ray
Osteichthyes	Acipenseriformes	Acipenseridae	*Acipenser medirostris*	Green sturgeon
			Acipenser transmontanus	White sturgeon

Class	Order	Family	Genus/Species	Common Name
	Clupeiformes	Clupeidae	*Alosa sapidissima*	American shad
			Clupea harengus pallasi	Pacific herring
			Dorosoma petenense	Threadfin shad
			Sardinops sagax caeruleus	Pacific sardine
		Engraulidae	*Engraulis mordax*	Northern anchovy
	Salmoniformes	Salmonidae	*Oncorhynchus tshawytscha*	Chinook salmon
			Oncorhynchus kisutch	Coho salmon
			Salmo gairdneri gairdneri	Steelhead trout
		Osmeridae	*Allosmerus elongatus*	Whitebait smelt
			Hypomesus pretiosus	Surf smelt
			Hypomesus transpacificus	Delta smelt
			Spirinchus starksi	Night smelt
			Spirinchus thaleichthys	Longfin smelt
	Cypriniformes	Cyprinidae*	*Cyprinus carpio*	Carp
			Carassius auratus	Goldfish
			Hesperoleucus symmetricus	California Roach
			Lavinia exilicauda	Hitch
			Mylopharodon conocephalus	Hardhead
			Notemigonus crysoleucas	Golden Shiner
			Orthodon microlepidotus	Sacramento Blackfish
			Pimephales promelas	Fathead Minnow
			Pogonichthys macrolepidotus	Splittail

Class	Order	Family	Genus/Species	Common Name
			Ptychocheilus grandis	Sacramento squawfish
		Catostomidae*	*Catostomus occidentalis*	Sacramento sucker
	Siluriformes	Ictaluridae*	*Ictalurus catus*	White catfish
			Ictalurus punctatus	Channel catfish
			Ictalurus melas	Black bullhead
			Ictalurus nebulosus	Brown bullhead
	Batrachoidiformes	Batrachoididae	*Porichthys notatus*	Plainfin midshipman
	Gadiformes	Gadidae	*Microgadus proximus*	Pacific tomcod
		Merluccidae	*Merluccius productus*	Pacific hake
		Ophidiidae	*Chilara taylori*	Spotted cusk-eel
	Atheriniformes	Scomberesocidae	*Cololabis saira*	Pacific saury
		Cyprinodontidae	*Lucania parva*	Rainwater killifish
		Poeciliidae	*Gambusia affinis**	Mosquitofish
		Atherinidae	*Atherinops affinis*	Topsmelt
			Atherinopsis californiensis	Jacksmelt
			Menidia audens	Mississippi silverside

Class	Order	Family	Genus/Species	Common Name
			Menidia beryllina	Inland silverside
	Gasterosteiformes	Gasterosteidae	*Gasterosteus aculeatus*	Threespine stickleback
		Syngnathidae	*Syngnathus leotorhynchus* (=griseolineatus)	Bay pipefish
	Perciformes	Percichthyidae	*Morone saxatilis*	Striped bass
		Centrarchidae*	*Archoplites interruptus*	Sacramento perch
			Lepomis cyanellus	Green sunfish
			Lepomis gibbosus	Pumpkinseed
			Lepomis macrochirus	Bluegill
			Lepomis gulosus	Warmouth
			Micropterus salmoides	Largemouth bass
			Pomoxis annularis	White crappie
			Pomoxis nigromaculatus	Black crappie
		Percidae*	*Percina macrolepida*	Bigscale logperch
		Sciaenidae	*Genyoemus lineatus*	White croaker
			Seriphus politus	Queenfish
		Embiotocidae	*Cymatogaster aggregata*	Shiner surfperch
			Damalichthys vacca (Rhacochilus vacca)	Pile surfperch
			Embiotoca jacksoni	Black surfperch
			Embiotoca lateralis	Striped surfperch

Class	Order	Family	Genus/Species	Common Name
			Hyperprosopon argenteum	Walleye surfperch
			Hyperprosopon anale	Spotfin surfperch
			*Hysterocarpus traski**	Tule perch
			Micrometrus minimus	Dwarf surfperch
			Phanerodon furcatus	White surfperch
			Rhacochilus toxotes	Rubberlip surfperch
			Hypsurus caryi	Rainbow surfperch
			Amphistichus argenteus	Barred surfperch
			Amphistichus rhodoterus	Redtail urfperch
			Brachyistius frenatus	Kelp surfperch
			Micrometrus aurora	Reef surfperch
		Clinidae	*Gibbonsia metzi*	Striped kelpfish
		Cebidichthyidae	*cebidichthys violaceus*	Monkeyface prickleback
		Pholidae	*Pholis ornata*	Saddleback gunnel
		Anarhichadidae	*Anarrhichthys ocellatus*	Wolf-eel
		Ammodytidae	*Ammodytes hexapterus*	Pacific sandlance
		Gobiidae	*Acanthogobius flavimanus*	Yellowfin goby
			Clevelandia ios	Arrow goby
			Gillichthys mirabilis	Longjaw mudsucker
			Ilypnus gilberti	Cheekspot goby
			Lepidogobius lepidus	Bay goby
			Tridentiger trigonocephalus	Chameleon goby
			Eucyclogobius newberryi	Tidewater goby
		Stromateidae	*Peprilus simillimus*	Pacific butterfish (=pompano)
		Scorpaenidae	*Sebastes atrovirens*	Kelp rockfish
			S. auriculatus	Brown rockfish
			S. flavidus	Yellowtail rockfish
			S. melanops	Black rockfish
			S. mystinus	Blue rockfish
			S. paucispinis	Bocaccio
			S. rastrelliger	Grass rockfish
			S. saxicola	Stripetail rockfish
			S. serranoides	Olive rockfish
		Hexagrammidae	*Hexagrammos decagrammus*	Kelp greenling
			Ophiodon elongatus	Lingcod
		Cottidae	*Artedius notospilotus*	Bonyhead sculpin
			*Cottus asper**	Prickly sculpin
			Cottus aleuticus	Coastrange sculpin
			Enophrys bison	Buffalo sculpin
			Leptocottus armatus	Staghorn sculpin
			Nautichthys oculofasciatus	Sailfin sculpin
			Scorpaenichthys marmoratus	Cabezon

Class	Order	Family	Genus/Species	Common Name
			Hemilepidotus hemilepidotus	Red Irish lord
		Liparidae (=Cyclopteridae)	*Liparis pulchellus*	Showy snailfish
	Pleuronectiformes	Bothidae	*Citharichthys stigmaeus*	Speckled sanddab
			Paralichthys californicus	California halibut
			Hippoglossina stomata	Bigmouth sole
		Pleuronectidae	*Hypsopsetta guttulata*	Diamond turbot
			Parophrys vetulus	English sole
			Platichthys stellatus	Starry founder
			Psettichthys melanostictus	Sand sole
			Lyopsetta exilis	Slender sole
			Pleuronichthys decurrens	Curlfin turbot
		Cynoglossidae	*Symphurus atricauda*	California tonguefish

Note: (*) indicates freshwater fishes occasionally found in marine areas during winter months.

Sources: Herald and Ripley 1951; Herald and Simpson 1955; Ganssle 1966; Messersmith 1966; Aplin 1967; PGandE 1973a, b; deWit 1975; Steitz 1975a,b; Ecological Analysts, unpublished data.

[a]Marine fish names from Miller and Lea (1972, 1976); others from Bailey *et al.* (1970).

APPENDIX J

Glossary of Terms and Acronyms

Glossary of Terms

Term	Definition
µ	Micron - a metric unit of measure, one millionth of a meter
Absorb	When a particle takes up or binds a chemical contaminant
Accretion	Filling of the bay floor by deposition of sediment, relative to a previous time period
ACOE	United States Army Corps of Engineers
Acoustic Profiling	Investigation of bay bottom or sub-bottom features by reflected acoustic energy, "profile" indicates the cross-sectional form of typical data display
Additive	Producing an effect (e.g., drug response) when the causative factors acting together are the sum of their individual effects
Adsorb	When a particle takes up or binds a contaminant by absorption
Advective Transport	Particle movement associated with water currents
Agglomerate	When particles cluster or gather together
Aggregation	The process of collecting and combining particles
AHI	San Francisco Aquatic Habitat Institute
Alcatraz Shoal	Marine sand mining area in central San Francisco Bay
Alluvial	Sediment derived and transported downstream by a stream or river
Alluvial Deposits	Clay, silt, gravel, etc., deposited by running water from a stream or river
Ambient	Background or undisturbed conditions
Anadromous	Fish that live in coastal marine waters but return to spawn in fresh water
Anaerobic	In the absence of free oxygen
Angularity	The shape and angles of sedimentary particles
Anomalies	Deviation from a standard, different, abnormal
Anoxic	In the absence of free oxygen
Anthropogenic	Caused by human activity
Asphyxiation	To kill or make unconscious by lack of oxygen
ASTM	American Society for Testing of Materials
Auditory	Hearing - the ability to detect sound
Background Levels	Undisturbed or existing conditions (see ambient)

Backscatter Methodology	A method using reflected light to measure turbidity and suspended sediments
Ballast Water	Water held within a ship to improve vessel stability
Bar	A linear or curving deposit of sand or other unconsolidated sediment extending across a river or bay mouth
Basalt	A dark colored volcanic rock; a Franciscan complex rock type
Bathymetry	The underwater depth configuration
Bay Mud	Geologic formation name for recent, fine grained unconsolidated sediment deposits in San Francisco Bay
Bay-Delta Estuary	The geographic area where freshwater and saltwater mix between approximately Rio Vista, Stockton, and the Golden Gate
BCDC	Bay Conservation and Development Commission
Beach Sand	Sand occurring on beaches, grains are usually rounded by repeated wave action
Bedforms	Physical shapes in unconsolidated sediment on the floor of a body of water
Bedload	Sediment that is carried along the bed of a body of water, staying in nearly constant contact with the bed
Bedload Transport	Movement of bedload sediments by water currents
Bedrock	Hard rock deposits that underlie unconsolidated sediment or are exposed on the land or on the floor of a body of water
Behavioral Effects	Impaired homing or migration, create a barrier or impediment to migration, reduction in feeding rates, avoidance response, abandonment of otherwise suitable habitat and alter predator-prey relationships
Benthic Macroinvertebrates	Invertebrates (e.g., worms, etc.) that typically live within the top 12 inches of sediment on the bay floor
Benthic Organisms	Organisms that live within bottom substrates (e.g., clams, worms)
Benthos	See benthic organisms
Bioassay	A laboratory test to determine the effect of a substance or condition on the survival of a species
Biomass	Weight of organisms inhabiting a habitat
BOD	Biological oxygen demand
BPTCP	Bay Protection and Toxic Cleanup Program

Bulkheads	A physical structure (e.g., wall) used to stabilize and reduce erosion from a shoreline or channel
C	Centigrade – a measure of temperature
CalFed	Organization of state and federal resource and regulatory agencies participating in the management and funding of Bay-Delta restoration activities
CDC	California Department of Conservation
Carquinez Strait	Geographic area extending upstream from the Carquinez Bridge to Middle Ground Shoal
CDFG/CDFandG	California Department of Fish and Game
Central San Francisco Bay	Geographic area extending from the Golden Gate Bridge to the Bay Bridge to the Richmond San Rafael Bridge.
CEQA	California Environmental Quality Act
CFS (cfs)	A measure of water flow rate (cubic feet per second)
Chert	A deep-ocean sediment made up originally of the skeletons of a type of plankton called radiolarians; A silicic (silicon dioxide, chemically the same as quartz) rock, typically red-brown or green, formed from fossils of radiolarian plankton skeletons, A Franciscan complex rock type
Chlorophyll	Green photosynthetic pigment found in plants
Ciliary Bundles	Hair-like structures that detect sound within the ear
Clam Shell Dredging	A type of mechanical dredge that has two opposing buckets, shaped like a clam shell
Clast	A piece within sediment, generally a rock or shell fragment, but also a broken fragment of semi-consolidated sediment
Clay	Two meanings - 1) fine mineral particle, smaller than 2 (sometimes cited as 4) micron diameter; 2) clay minerals, which are sheet silicate minerals with poor bonding between sheets, resulting in being easily deformed when saturated
cm	Centimeter - a metric measure of length, one hundredth of a meter
cm/sec	A metric measure of water current velocity, centimeter per second
Cohesive Properties	The ability of particles to bond with one another
Colloidal	A state of suspension nullifying the settling tendency
Colloids	Particles in suspension within water or another medium
Colma Formation	Pleistocene age deposits of poorly consolidated sand on land in San Francisco Bay area; named for community of Colma south of San Francisco

Colonization	The process of organisms moving into an area and taking residence
Cone Penetrometer	Investigative tool that pushes a rod with a conical tip into unconsolidated sediments, producing data about the kind of sediment
Contaminant	An undesirable chemical or physical constituent of sediment or water, generally a product of anthropogenic activity
Continental Shelf	Low relief, relatively shallow area off shore of ocean coast, inshore of continental slope and abyssal ocean
Correlation	A mathematical or statistical relationship between two variables
CPT	Cone Penetrometer
CPUE	Catch-per-unit-effort: a measure of fish density
Critical Habitat	Habitat identified under the ESA that is required for the protection and conservation/recovery of listed species
Critically Dry Years	A classification denoting the driest hydrologic conditions within a watershed
Crustacean	A variety of aquatic macroinvertebrates having an external skeleton, including crabs and shrimp
Cumulative Impacts	Impacts from two or more sources, which, when considered together are considerable
Cutter Jets	A series of jets in the drag head
Cutterhead	A hydraulic suction head using a mechanical or water jet to loosen sediment particles
CVP	Central Valley Project
cy	Cubic yards – a measure of material volume
dB	Decibels – a measure of sound intensity
Deep River Channels	River channels characterized by depths of more than 20 feet and strong tidal and river currents, typically 30-40 cm/sec (1.1-1.5 ft/sec) or more
Defaunation	The removal of plants and/or animals from an area
Deformation	Change of shape of geologic material, generally caused by tectonic activity
Delta	An area of deposition of unconsolidated sediment within a water flow system, typically fan-shaped due to a narrow channel entering a wider body of water; Sacramento/San Joaquin river low relief area on the east side of the Coast Range
Delta Outflow Index	A calculation performed by DWR to estimate the magnitude of freshwater passing downstream through the delta into San Francisco Bay
Demersal	Organisms that live on or near the bottom

Demersal Adhesive Eggs	Eggs that stick (adhere) to the bottom substrate during spawning and incubation
Densities	Number of organisms per unit volume or unit area
Depletion	Loss of unconsolidated sediment from bay floor, relative to a previous time period
Desiccation	To dewater, dry out, or dehydrate
Detritivores	Organisms that feed on decaying organic matter
Detritus	Decaying organic matter
DGPS	Differential global positioning system
Digenetic	Chemical change of mineral grains within sediment or sedimentary rock
Diking	The physical process of creating a levee or structure to exclude water from an area
Discharge	Outflow of water from a water body; may also refer to the quantity of the outflow
Dispersion Times	Time required for concentrations of material (e.g., overflow plume) to return to background levels
Dissipation	To disperse or scatter
Diurnal	Approximately twice per day
Diversion	Anthropogenic re-direction of flow of water in or away from a natural course; generally for water use or flood control purposes
Diversity Indices	A statistical measure of the number of species inhabiting an area
DO	Dissolved oxygen
DOER	Division of Energy Resources
Dose Response	Relationship between a biological reaction or response, whether lethal or sublethal (the response) and the concentration of sediment the organism is exposed to over a given time period (the dose)
Drag Arm	A pipe extending from a sand mining barge down to the drag head
Drag Head	The structure at the end of the drag arm in contact with the substrate during mining or dredging (also referred to as a suction head)
Drainage	Land area from which runoff of precipitation contributes to a water body
Dredge Spoil	Material from navigational channel (or other) dredging; generally not commercially saleable, therefore must be disposed
Dry Years	A classification of hydrologic conditions within a watershed

Dune Sand	Sand occurring in dunes, deposited by wind (aeolian activity)
DWR	Department of Water Resources
Earthquake	Shaking of the earth caused by geologic (tectonic) forces
Ebb Delta	A delta deposited by ebb tide (outward or seaward) flow
Ebb Tide	Portion of tidal cycle when water level is falling
Eddy	A water current moving in a circular direction or against the main current flow
Effective Velocity	Velocity of the current in contact with the channel bed
EFH	Essential Fish Habitat
Emigration	Downstream migration
Entrainment	The direct uptake of aquatic organisms by the suction field generated at the draghead
EPA	Environmental Protection Agency
Ephemeral	Occurring only part of the year
Epibenthic Macroinvertebrates	Organisms that typically live on the sediment surface, such as shrimp and crabs
Epicenter	The map location of the beginning of motion of an earthquake
Epiphytes	A plant that depends on a physical surface (e.g., rock) for physical attachment/rooting
Episodic	An event that occurs on an irregular or periodic time scale
Epithelia	A cell layer covering the exterior and interior of a body; skin
Equivalent Adult	A mathematical technique for assessing the potential impacts of mortality to various lifestages in terms of the expected number of organisms that would have survived to become reproductive adults had the mortality not occurred.
Erosion	Process of removal of earth surface material, including material from the floor of a body of water, generally by action of water or wind
ESA	California and/or federal Endangered Species Acts
Estuarine	Found or present within an estuary
Estuary	Area between a river and bay where freshwater and saltwater mix
Estuarine System	Body of water connected to the ocean, subject to tidal action, may also mean the geomorphic depression that contains the body of water
Euhaline	$\geq$ 30 ppt salinity

Exotic Species	Nonindigenous, originating from another part of the world
Fathometer	Instrument used to measure water depth
Fault, Fault Zone, Strike Slip, Conjugate Fault	Plane of contact between two masses of the earth that move, or have moved, relative to each other; zone of such planes near each other; strike slip means the motion is horizontal on a vertical plane; conjugate fault is inclined fault plane geometrically consistent with forces producing the initial fault plane
Feldspar	A common rock-forming silicate mineral; alters by chemical weathering to clay mineral
Filter Feeding	Organisms that feed by filtering plankton and organic material from the water
Fine Sediment	Small (fine)-grained inorganic material (e.g., silts and clay)
Fines	See fine sediment
Fish	Cold-blooded organisms from the superclass *Pisces*
Flocculation, Floc	Aggregation of a number of fine suspended particles; mass formed by such aggregation
Flood Delta	A delta deposited by flood tide (inward or landward) flow
Flood Tide	Portion of tidal cycle when water level is rising
Fluvial	Pertaining to or inhabiting a stream or river
Food Web	The complex association between predators and their prey
Foot/Second	Measure of velocity (see ft/sec)
Formation	Geologic term for an identifiable body of geologic material; specifically units of sedimentary rock
Franciscan Complex/Formation	An assemblage of rock types that is characteristic of coastal California, named for San Francisco; includes various sedimentary, volcanic, and metamorphic rocks formed in the deep ocean or in a subduction zone
Fresh Water	Water derived from precipitation, with a relatively low concentration of dissolved material
Ft/Sec	Measure of velocity (foot per second)
ft^3	Measure of volume (cubic foot)
Geologic Time	The time period during which geologic processes have operated; the naming scheme used by geologists to denote different eras of this time
Geomorphic	Surface land shapes related to geologic processes
GIS	Geographic information system
Golden Gate	The narrow channel between San Francisco Bay and the Pacific Ocean
GPM	Gallons per minute

GPS	Global positioning system that uses satellite signals to triangulate a geographic location
Grab Sample	A sample of water or sediment that is collected at a particular time and place
Graben	An area between two faults that is lower than the areas to either side, down-dropped tectonic block
Gravel	Sediment that is coarser than sand, with grain diameter greater than 2 millimeters
Gravitational Circulation	Flow of water within an estuary that is driven by density contrasts between adjacent water masses, which are caused by salinity contrasts
Gravity	Attractive force of mass; the strength of the earth's gravitational field varies locally due to varying density of geologic materials, so measurements can be used to investigate subsurface features
Greenstone (altered basalt)	Chemically altered volcanic rock, a Franciscan complex rock type
Grizzly	A physical screen used to exclude oversized material
ha	Hectare - metric unit of area
Hanson	Hanson Aggregates Mid-Pacific
Harvest	(of sand) - mining of sand
Hematological	Pertaining to blood
Hemoglobin	Oxygen bearing iron-rich red blood cells
Hemorrhaging	Bleeding
Heterogeneous	Dissimilar elements, without inter-relationships
Histology	Anatomical study of organs and cell structures
Holocene	The most recent geologic time period, between the present and 11,000 years ago
Holocene in Age	Less than 11,000 years old
Holoplankton	Permanent members of the plankton
Homogeneously	Similar, uniform in structure and composition
Hopper Barges	A vessel with a hold for storing sand or other material
Hydraulic Mining	Gold mining technique of washing away deposits of unconsolidated sediment with high pressure water, resulted in transport of large quantities of sediment from the Sierra Nevada foothills to the Central Valley and Bay / Delta estuary in the late 1800s
Hydraulic Suction Dredge	Using water pressure to fluidize a material (sand) that can be transported in a slurry to a mining barge
Hydrophilic	An affinity for water, capable of dissolving in water
Hydrophobic	Antagonistic for water, incapable of dissolving in water
Hypothesis	An assertion capable of scientific testing

Hz	Hertz - a measure of sound wave frequency, cycles per second
Ichthyoplankton	Egg and larval forms of estuarine and marine fishes that passively drift with water currents
Inflow	Flow of water into a body of water of interest
Inorganic	Not composed of organic matter; especially minerals
Interannual	Among years
Intertidal Zone	The area along the margin of a bay that is submerged at high tide and exposed at the lowest tide
Jerico	Jerico Products/Morris Tug and Barge
KCY	Thousand cubic yards
kHz	One thousand hertz, a measure of sound frequency
km	Kilometer, one thousand meters
Knots	Measure of vessel speed, nautical miles per hour
K-Selected	Slower-growing species, lower reproduction
Lamella	Fine filamentous structure on a gill that facilitates oxygen exchange
Lateral Line	A series of nerve endings along the side of a fish that detect sound, turbulence, and pressure
lb/cf	Pounds per cubic foot
LC10	Concentration of a toxicant resulting in 10% mortality after a set duration of exposure (e.g., 24 hours)
LC50	Concentration of a toxicant resulting in 50% mortality after a set duration of exposure (e.g., 24 hours)
LC90	Concentration of a toxicant resulting in 90% mortality after a set duration of exposure (e.g., 24 hours)
Lethal Effects	Effects that result in mortality of individuals, cause population reductions, or damage the capacity and function of habitats to support various species and lifestages
Lethargy	Sluggish, slow to respond, unconsciousness
LGM	Last glacial maximum - the time of most recent maximum extent of glaciers, approximately 17,000 years ago; "Ice Age"
Limestone	Sedimentary rock composed of calcium carbonate, generally made up of shell fragments
Littoral	Shore zone between high and low tide levels, used to describe near-shore processes
Littoral Cell	Length of ocean coast with connected sand transport
Loaded Draft	Water depth for a vessel when fully loaded with cargo, minimum water depth for a loaded vessel to float

Loading Chute	A pipeline or channel used to distribute sand within a sand mining barge
Longshore Current	Ocean water current parallel to the shore, usually caused by wave energy
Longshore Transport	Movement of sand by ocean water currents along (parallel) to an ocean beach
Loss of Equilibrium	Becoming disoriented, unable to maintain balance or orientation
LSZ	Low Salinity Zone
m	Meter - a metric unit of length
Macroalgae	Large aquatic plants, not phytoplankton
Macroinvertebrate	Large aquatic organisms such as shrimp, crabs, worms, clams, etc.
Marble	Metamorphic rock composed of calcium carbonate, formed by recrystallization of the calcium carbonate in limestone
Marine	Having to do with salt water bodies; the mined sand from San Francisco Bay estuary is called "marine sand"
Mega Ripples	Large-scale sand waves
Merced Formation	Pleistocene age deposits of poorly consolidated sand on land and offshore in San Francisco area; named for Lake Merced in southern part of San Francisco
Meroplankton	Members of the plankton only during early life-stages
Mesohaline	1-18 parts per thousand (ppt) salinity range in water
Metadata	A description of a data set, units of measure, methods, etc.
mg/l	A measure of concentration based on weight per volume
Mica	A silicate mineral that forms flat, shiny flakes
Microbes	Microscopic organisms, bacteria
Microhabitat	The environmental conditions in the immediate vicinity of habitat occupied by an individual or species
Microhematocrit	Measure of red blood cell volume
Middle Ground Shoal	Marine sand mining area within western Suisun Bay
Mineralogy	Study of inorganic rocks and minerals
Mixing Zone	The area within an estuary where freshwater and saltwater mix
MLLW	Mean lower low water
mm	Millimeter - a metric unit of length, one thousandth of a meter
MMS	Minerals Management Service
Monterey Formation	Sedimentary rock unit, mainly shale, common in coastal California

Mooching	A method of fishing while drifting with a current
Morphology	Biological study of the form and structure of living organisms
Moving Potholing	Involves mining while moving over a site as well as trying to mine in a stationary position when an appropriate sand source is found
Mud	Fine grained, unconsolidated, saturated sediment; made up of silt and clay size particles
Mudflats	Intertidal area characterized by silt and mud substrate
Multibeam Backscatter	The energy that is returned to the multibeam sidescan sonar instrument, strength of the energy indicates bottom features
Multibeam Survey	A sidescan sonar technique for imaging the floor of bodies of water using reflected energy
Multiple-Event Days	Occurrence of two or more sand mining events within an area during one day
Neap Tide	Tide of least change; a tide of minimum range occurring at the first and third quarters of the moon
Nekton	Actively swimming organisms
NEPA	National Environmental Policy Act
New York Slough Channel	A navigation channel located in the lower San Joaquin River near Antioch
NMH	Nautical miles per hour
NOAA	National Oceanographic and Atmospheric Administration
Nonindigenous	Species originating from areas outside of the Bay-Delta estuary (see exotic)
Nonnative	Species originating from locations outside of the estuary
Nonobligate Species	May or may not inhabit the estuary during any give year
NOS	NOAA National Ocean Service
NS&T	National Status and Trends Program
Obligate Species	Reproduction and rearing of juveniles occurs almost exclusively with a Bay or estuarine environment
Ocean	Large salt water body; specifically the Pacific Ocean west of Golden Gate
Ocean Beach	The beach on the west side of San Francisco
Open Water (Pelagic) and Deep Subtidal Zone	The offshore open waters and deep subtidal habitat begins at a depth of about 30 feet, reflecting the differences in light penetration and other variables
Opportunistic Species	Species that use the Bay-Delta estuary as an extension of their habitat based on the suitability of environmental conditions

Organic Matter	Matter produced by living organisms
Osmolarity	A measure of salt concentration in a solution
Outcrop	Location where a particular type of rock, usually bedrock, is exposed at the land surface, including the floor of a body of water
Overflume Plume	Water discharged overboard during sand mining that contains suspended sediments and other material
P	Probability of statistically significant differences
PAHs	Polycyclic (or polyaromatic) aromatic hydrocarbons
Paleo-	Describes a feature associated with past geologic time
Paleo-Channel, Paleo River Channel	Topographic or bathymetric canyon of a river that existed in the geologic past, particularly offshore in areas that were exposed during low sea level stand
Particle	An individual piece of matter, usually rock, within sediment
Particulate	Characterized as a particle, often referring to particles in water
Peat	Almost pure carbon formed by decomposition of tule marsh material
Pelagic Herbivores	Organisms that live in the water column and forage on plant material (e.g., phytoplankton)
PFMC	Pacific Fisheries Management Council
PG&E	Pacific Gas & Electric Company
Photic Zone	Area within the water column where sufficient sunlight penetrates to support photosynthesis by aquatic plants
Photoperiod	The duration within a day that organisms are exposed to sunlight
Photosynthesis	Process used by green plants to convert sunlight into chemical energy
Photosynthetic Plants	Green plants that can convert sunlight into chemical energy and organic compounds
Phytoplankton	Single and multi celled plants that passively drift with water currents
Plankton	Plants, invertebrates, and fish that passively drift with water currents during all or a part of their life cycle
Plate Boundary	The location of contact between geologic portions of the earth that are moving relative to each other
Pleistocene Geologic Period	The last 2 million years
Pleistocene Merced Formation	A deposit of shallow marine and non-marine silts and sands
Pleistocene	A recent geologic period, between approximately 11,000 years ago and 2,000,000 years ago

Plume Zone	Area or volume within the water column where the overflow plume from sand mining is present
Plume, Overflow Plume	A mass of water within a larger water body that has some distinct characteristic; overflow plume is characterized by suspended fine sediment washed from sand during sand mining dredging
Point Knox Shoal	Marine sand mining area in central San Francisco Bay
Polyhaline	18-30 ppt
Potholing	Potholing involves an initial search for an appropriate sand source
PPM (ppm)	Parts per million
PPT (ppt)	Parts per thousand
Presidio Shoal	Marine sand mining area in central San Francisco Bay
Pressure Ridge	Linear hill in a fault zone caused by compression oblique to strike slip motion
Primary Producers	Green plants that convert sunlight into chemical energy through photosynthesis
Productivity	The process of producing organic matter
Quadrilaterals	A four sided shape, on maps of San Francisco Bay used to denote one minute of latitude by one minute of longitude
Quartz	A mineral composed of silicon dioxide (silica); relatively resistant to mechanical and chemical breakdown; common constituent of sand
Radiolarian Fossils	Siliceous skeletons of radiolarian plankton, preserved in rocks, especially chert
Radiolarians	Marine protozoan with a rigid siliceous skeleton
Ready-Mix	A type of concrete, generally delivered in trucks from plants where it is mixed with aggregate, and water to form cement
Recolonization	Re-establishment of organisms within an area following disturbance
Recruitment	Introduction of new individuals or materials into a habitat or population/lifestage
Regressions	Statistical technique for assessing the relationship between two variables
Replenishment	Increase in the quantity of sand in a sand mining area, due to deposition of sand transported from elsewhere
Residence Time	Period of time that suspended sediments remain in the water column
Rhyolite	A type of volcanic rock, generally light colored
Riprap	Rock or other hard material used to reduce erosion and stabilize channel banks and shorelines
RMC Group PLC (RMC)	RMC Pacific Materials - part of the RMC Group PLC

RMP	Regional Monitoring Program
Rock	A naturally occurring solid earth material; an exposure of bedrock, particularly one protruding from the floor of a body of water
Roe	Fish and macroinvertebrate eggs
R-Selected	Rapid-growth species
RWQCB	California Regional Water Quality Control Board
Sag Pond	A depression in a fault zone, filled with water
Salinity	The presence of dissolved salt (sodium chloride) in water; the concentration of dissolved salt in water
Salinity Gradient	Variation of the concentration of dissolved salt within a body of water
Salmonids	Group of cold-water fish including Chinook salmon and steelhead
San Francisco Bar	An accurate bathymetric feature in the ocean seaward of Golden Gate
Sand	Solid material with particle size between 0.063 millimeter and 2 millimeters; generally rock and shell particles
Sand Mining	Excavation of sand; in the San Francisco Bay estuary sand is sold as construction material
Sand Scow	A sailing vessel used historically to harvest sand from San Francisco Bay
Sand Waves	Forms in unconsolidated sediment on the bottom of a body of water with wave-like shape
Sand-Water Slurry/Slurry	A sand and water mixture-approximately 23% sand and 77% water at Middle Ground and 27% sand and 73% water in Suisun Bay
Schist, Blueschist, Quartz Schist	Metamorphic rock with flat, platy nature; blueschist is blue in color due to blue minerals; quartz schist is characterized by presence of quartz; a Franciscan complex rock type, also found in Sierra Nevada and elsewhere
Sea Level	Average vertical elevation of the ocean surface; used as a reference for topographic elevations and bathymetric depths; subject to change during geologic and historic time
Sea Level Rise, Low Stand	Rise - the upward movement of sea level during geologic time, particularly since the last glacial maximum; low stand - the minimum elevation of sea level during the last glacial maximum, approximately 120 meters (390 feet) lower than present sea level
Secchi Disk	A plastic or painted disk, typically with alternating black and white quadrants, used to measure water transparency

Secchi Disk Transparency	Water depth that a Secchi disk can be visually detected
Sediment	Geologic material that has been deposited following transport in water or air; also such material while it is being transported
Sediment Budget	A quantification of the erosion, transport, and deposition of sediment, particularly within a geographic area or body of water such as an estuary
Sediment Core	A sample of sediment collected by driving a tube into the earth surface, particularly the floor of a body of water
Sediment Dynamics	The motion of sediment, or the understanding of such motion, particularly within a body of water
Sediment Load	The quantity of sediment that is transported by a body of water (or air)
Sedimentary Basin	A geologic depression that is filled with sediment, may or may not correspond to a topographic basin
Sedimentary Fill	The material that fills a sedimentary basin
Seismic Reflection	Investigative technique used to image the earth's subsurface by reflecting acoustic energy from contrasts between rock or unconsolidated sediment types
Semi-Buoyant Eggs	Neutrally or slightly negatively buoyant eggs that slowly sink
Semidiurnal	Twice daily
Semidiurnal Ocean Tides	Two high tides and two low tides daily
Serpentine	A silicate mineral, or metamorphic rock composed of the mineral serpentine, usually green or reddish brown, a Franciscan complex rock type
Settling Rate	Time required for sediment particles to settle (sink) a given distance within a water column
SFBRWQCB	San Francisco Bay Regional Water Quality Control Board
SFEI	San Francisco Estuary Institute
Shale	A fine-grained sedimentary rock that breaks easily into thin, flat layers
Shallow-Water Habitat	Aquatic habitat typically less than 9 feet deep at MLLW
Shoal Areas	The area between the shore and deepwater ship channel characterized by water depth less than 20 feet, a mud or mud-sand bottom, and reduced tidal and river currents
Shoals	An area of sediment accumulation within a waterbody characterized by shallow water depths

Silica, Silicate	Silica - a mineral of composition silicon dioxide, of which quartz is the most common; silicate - a mineral composed of various other elements in combination with silicon and oxygen; most of the mined sand is silica or silicate
Silt	Fine grained sediment, between 2 (sometimes cited as 4) - 62 (sometimes cited as 63) micron particle diameter
Slack Tide	Tidal stage following a flood tide and before the ebb/following the ebb and before the flood
SLC	California State Lands Commission
SMARA	Surface Mining and Reclamation Act
SMB	California State Mining Board
Sonographic	Bathymetric surveys and mapping using underwater sound pressure
Species of Special Concern	Designation given by CDFG to a species whose abundance or distribution has declined substantially that warrants an increased level of consideration and protection
Specific Gravity	Weight of a material or fluid
Spring Tide	Tide of maximum range, occur twice each lunar month at new moon and full moon
SSC, TSS	Suspended solid concentration, total suspended solids - quantification in mg/L of amount of suspended particulate matter in water
SSCs	Suspended sediment concentrations
Standing Crop	The instantaneous abundance or biomass of a species
Stationary Mining	Mining of sand at a site, typically while anchored
Statistically Significant	A mathematical measure of the probability that observed differences between two variables may occur by chance
Structural (Geological)	Shape of surface or subsurface geologic feature that is due tectonic motion or force
Subduction Zone	Interface between a geologic plate that is being transported downward into the earth and the adjacent surface plate
Sublethal	A biologically (physiological) response such as reduced growth rate, increased stress, reduced health, that does not result in direct mortality. Effects that result in reduced growth rates, physiological stress, histological damage, moderate habitat degradation, reduced health or condition of individuals, etc.
Subtidal Zone	The subtidal zone extends offshore from the lowest area exposed by the tide (MLLW)

Succession	The sequence in which one species replaces another within a habitat
Suction Head	See Drag Head
Suisun Associates	A joint venture between Hanson and Jerico
Suisun Bay	Eastern portion of the San Francisco Bay estuarine system; region extending upstream from Middle Ground Shoal to New York Slough within the western delta
Suspended Load	The portion of sediment load within a body of water that is transported in suspension
Suspended Sediment	Sediment that is held in suspension within body of water
SWP	State Water Project
SWRCB	State Water Resources Control Board
Synergistic	Response of an organism to two or more factors that is greater than the sum of the individual factors alone
T/CY (T/cy)	Tons per cubic yard
Tectonic	Geologic feature (motion, force, etc.) associated with dynamic motions of the earth
Tidal	Associated with or caused by the motion of the tides, particularly ocean tides; caused by gravitational forces of extraterrestrial objects, particularly the sun and moon
Tidal Exchange	Volume of water entering or exiting San Francisco Bay on a tidal cycle
Tidal Jet	A high velocity current within a body of water caused by tidal forces
Tidal Prism	The volume of water that enters and leaves a bay during a tidal cycle; called "prism" because a cross section of the water volume between the high and low tide levels in a small bay would have a prismatic shape
TLS39 or Grossi	Privately held sand mining lease area located in the Middle Ground Shoal area of Suisun Bay
TOC	Total organic carbon
Trailing Arm	See Drag Arm
Tributary	A river or creek that flows into a larger body of water
Trolling	Involves mining while moving over a site, generally working back and forth along parallel pathways between markers
Trophic Levels	Relationship among species based on predator-prey feeding

TSS, SSC	Total suspended solids, suspended solid concentration - quantification in mg/L of amount of suspended particulate matter in water
Tsunami	A large, rapid ocean wave caused by displacement of the sea floor, generally due to earthquake or landslide; often destructive to coastal areas
Turbidity	Cloudiness of water; quantification of cloudiness by transmission of light
Turbulence	Water currents that are highly variable in both direction and velocity, violently disturbed water currents
UK	United Kingdom
Unconsolidated Sediment	Accumulation of sediment that is held together by gravity, but without chemical or physical bonding between particles
Upwelling	Upward motion of water within a body of water, particularly of water with different characteristics than the water originally at the surface
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service
USGS	United States Geologic Survey
Vascular Plants	Plants having supportive tissue containing vessels for fluid circulation
Water Column	Area within an aquatic habitat between the bottom and surface
WESCO	Western Ecological Services Company
Wet Years	A hydrologic classification for watershed runoff
Year-Class Strength	A measure of the abundance of a specific age class of a species
Young-of-the-Year	Juvenile fish in their first year of life
Zooplankton	Microscopic and macroscopic animals that are planktonic (free-floating) or weak swimming fish and invertebrates

(Footnotes)

[1] Note that References refers to listed references within Literature Cited, Section 10.

[2] **California's Living Marine Resources: A Status Report, California Department of Fish and Game, 2001.**